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BRINKS HOFER GILSON & LIONE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of: Robert G. Everts, et al.

Appln. No.: 10/666,924

Filed: September 19, 2003

For: OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD

Examiner: Noah P. Kamen

Art Unit: 3747

Attorney Docket No: 10512/41

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Sir:

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						Small Entity			Not a Small Entity	
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Respectfully submitted,

9-12-05
Date

Benjamin B. Cotton (Reg. No. 54,050)

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Date of Deposit: September 12, 2005

Atty. Ref. No.: 10512/41

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

ROBERT G. EVERTS, et al.

Serial No.: 10/666,924

Filing Date: September 19, 2003

For OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD

Examiner: Noah P. Kamen

Group Art Unit No.: 3747

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is an appeal from the Office Communication dated June 27, 2005 in response to the Applicants' reply filed June 13, 2005 regarding the Examiner's assertion that the application is not in condition for allowance. The Examiner explained in the Advisory Action dated June 27, 2005 that the Applicants' arguments concerning motivation to combine and miniaturization, inoperability of

combination, and destroying the references were not deemed persuasive as already set forth in the final rejection.[1]

I. REAL PARTY IN INTEREST

The real party in interest is the assignee of the present patent application, MTD Southwest, Inc.

Bank One, N.A. has a security interest assigned to it by MTD Southwest, Inc.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

III. STATUS OF CLAIMS

The status of the claims is as follows:

Claims 1-7 have been cancelled.

Claims 8-19 are pending in the present application.

Claims 8-19 are finally rejected under 35 U.S.C. § 103(a) as being unpatentable over Kovacs (DE 3335962) in view of Takada et al. (JP 61-39416).

IV. STATUS OF AMENDMENTS

All amendments have been entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Applicants disclose and claim the first hand-held, power tool utilizing a four-cycle engine adapted to be carried by an operator in use. Before Applicants' invention, operator-carried, hand-held power tools existed, but they used electric motors or two stroke engines, not four cycle engines as claimed. Independent

[1] On July 13, 2005, Appellants filed a Notice of Appeal. Since the Notice of Appeal was filed within three months of the mailing date of the Final Office Action and the present Appeal Brief is being filed within two months of the filing of the Notice of Appeal, the present Appeal Brief is timely filed.

Claims 8 and 14 are directed to a hand-held, portable power tool having a lightweight, four-cycle engine. An exemplary embodiment of a hand-held, portable power tool is shown in the application, attached hereto at Tab A, in Figure 1 and described at page 5 line 26 through page 6, line 10. The portable power tool includes a frame (22) to which a handle (24, 26) is operatively attached thereto. A rotary-driven implement (32) cooperates with the frame (22). The handle allows a user to grasp the frame and control the movement of the implement. The implement is disposed at one end of the frame such that the weight of the implement is balanced by an engine (30) disposed at the opposing end of the frame.

The key to Applicants' invention is the use of a novel four-cycle engine instead of the conventionally used two-cycle engine. Before Applicants' invention, a four-cycle engine had never been used for a hand-held, operator-carried power tool. Indeed, it was impossible because four-cycle engines weighed in excess of 40 pounds. Judith Anne Gunther, *The Little Engine that Could*, Popular Science, March 1993, at 90, 92.[2] Such an engine could never be used in a hand-held, operator-carried application. Applicants' engine was uniquely designed so that it was compact and light enough to be used on an operator-carried, hand-held power tool. It also included a lubrication system that enabled the tool to be used in a wide variety of orientations.

The engine is lightweight and compact as a result of the materials used, and the engineered design and architecture. The engine design and lubrication system is shown in Figures 2-10 and fully described in the specification beginning on page 5, line11 through page 10, line 22.

[2] This article was first made of record in an Information Disclosure Statement with the originally-filed application on September 19, 2003 as reference A48. Because the Applicants had received no indication that the Examiner had considered this reference prior to the filing of the Request for Continued Examinatin, this article was re-submitted in an Information Disclosure Statement with the Request for Continued Examination on November 12, 2004 as reference B56. The relevant portions of this article were then explained to the Examiner by the Applicants in the Amendment filed on March 28, 2005 and in the Response to Office Action filed June 13, 2005.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether Claims 8-19 are obvious under 35 U.S.C. § 103(a) with respect to Kovacs in view of Takada et al.

VII. ARGUMENT

A. Claims 8-19 are not obvious under 35 U.S.C. § 103(a) with respect to Kovacs in view of Takada et al.

Claims 8-19 were finally rejected in the Final Office Action of April 14, 2005 under 35 U.S.C. § 103(a) as being obvious with respect to Kovacs (DE 3335962), attached hereto at Tab B, in view of Takada et al. (JP 61-39416), attached hereto at Tab C.

1. Examiner Failed to Establish a *Prima Facie* Case of Obviousness

During prosecution of a patent application, the Examiner has the initial burden of establishing a *prima facie* case of obviousness under 35 U.S.C. § 103. *In re Fine*, 837 F.2d 1071, 1074 (Fed. Cir. 1992). According to the Manual of Patent Examining Procedure, three criteria must be met in order for the Examiner to establish a prima facie case of obviousness. MPEP § 706.02(j). First, the Examiner must be able to show "some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings." *Id.* Next, "there must be a reasonable expectation of success." *Id.* Finally, "the prior art reference (or references when combined) must teach or suggest all the claim limitations." *Id.*

The Examiner can satisfy this burden only by showing some objective teaching in the prior art or knowledge of one skilled in the art that would lead one to combine the teachings of the relevant references. *In re Fine*, 837 F.2d at 1074. Merely because references can be combined or modified does not render the resultant combination obvious unless the desirability of the combination is suggested in the prior art. MPEP § 2143.01 (citing *In re Mills*, 916 F.2d 680 (Fed. Cir. 1990)). The Federal Circuit has required that "particular findings must

be made as to the reason the skilled artisan, with no knowledge of the claimed invention, would have these components for combination in the manner claimed." *In re Kotzab*, 217 F.3d 1365, 1371 (Fed. Cir. 2000). Additionally, identification of each claimed part in the prior art is insufficient to defeat patentability of the whole claimed invention. *Id.* An element-by-element or limitation-by-limitation analysis of claims by picking and choosing claim elements or limitations from at least one piece of prior art is insufficient to establish obviousness without clearly pointing out a teaching or motivation to combine each of the elements in the references. *In re Dembiczak*, 175 F.3d 994, 1000 (Fed. Cir. 1999). Moreover, "whether a particular combination might be "obvious to try" is not a legitimate test of patentability." *In re Fine*, 837 F.2d at 1075.

a. <u>There is No Motivation For Combining Kovacs and Takada et al. Because Combining Them Impermissibly Changes the Principle Operation of Those References</u>

In the present application, the Examiner has chosen aspects of Kovacs to be combined with aspects of Takada et al. on a limitation-by-limitation basis, but the Examiner fails to provide a teaching or showing that one of ordinary skill in the art would know or be prompted to make such a combination. Applicants submit that one of ordinary skill in the art would not be motivated to combine the teachings of Kovacs with those of Takada et al. because the combination would result in something that eliminates required features of one or both of the references. A combination that changes the principle of operation of the allegedly invalidating references is not sufficient to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 813 (CCPA 1959); see also *In re Fritch*, 972 F.2d 1260, 1265 n.12 (Fed. Cir. 1992); *In re Gordon*, 733 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984); MPEP § 2143.01. Here, Kovacs specifically discloses certain important engine features that are drastically different from those in Takada et al. For example, Kovacs requires that "the engine is built with an inlet and outlet *in the cylinder head*" (Tab B, p. 2). Further, Kovacs requires two inlet openings (Tab B, p. 2), the second being in the cylinder center (Tab B, p. 2). By comparison, Takada et al. requires that the inlet and outlet valves as well as the mechanism for operating the valves be "provided above the cylinder

head" (Tab C, p. 2). Thus, the structures of Kovacs and Takada et al. are not compatible and any combination of the two would significantly alter the structure disclosed by each of those references. In such a situation, the combination is improper and cannot establish a *prima facie* case of obviousness. *In re Ratti*, 270 F.2d at 813; see also *In re Fritch*, 972 F.2d at 1265 n.12; *In re Gordon*, 733 F.2d at 902; MPEP § 2143.01.

b. Examiner Provides No Teaching or Showing that There Would Be a "Reasonable Expectation of Success" in Combining Kovacs and Takada et al.

There also is no teaching in Takada et al. as to how the disclosed lubrication system is capable of being adapted to be incorporated into different engines, let alone the engine disclosed in Kovacs. Without further teaching, it would not be obvious to one skilled in the art to combine the lubrication apparatus of Takada et al. with the four-cycle engine of Kovacs. Indeed, their incompatibility supports that one of ordinary skill in the art would not be motivated to make this combination as there would not "be a reasonable expectation of success." MPEP § 706.02(j). This is especially the case in this situation where the combination would destroy prior art references. Hence, the Examiner has failed to provide a *prima facie* case of obviousness as required in the Manual of Patent Examining Procedure § 2143. Therefore, Applicants submit that Claims 8-19 are patentable over the prior art, and that the present apparatus is not an obvious combination of Takada et al. and Kovacs references.

2. Examiner's Reliance on an Unclaimed Feature Does not Provide Motivation to Combine References

With respect to Claims 8-13, these claims in the present form were originally allowed by the Examiner in the Notice of Allowability dated August 11, 2004 (Tab D). The Kovacs reference that the Examiner is now asserting against the claims of the present application was originally submitted in an Information Disclosure Statement and corresponding Form PTO-1449 accompanying the originally-filed application. The Notice of Allowability dated August 11, 2004 did not include the initialed Form PTO-1449 indicating that any of the references submitted by the Applicants had been considered by the Examiner. The issue

fee payment was due November 12, 2004, as indicated on the Notice of Allowability. The Examiner eventually considered the references submitted by the Applicants with the original application and disclosure and mailed a second Supplemental Notice of Allowability on November 4, 2004 (Tab E), one week before the issue fee payment was due. In this second Supplemental Notice of Allowability, the Examiner indicated that Claims 8-13 remained allowed in view of each piece of art submitted by the Applicants, which included the Kovacs reference.

The Kovacs reference was submitted and considered by the Examiner when the second Supplemental Notice of Allowability was mailed, and Claims 8-13 remained allowed. The Takada et al. reference that the Examiner is using in combination with the Kovacs reference to reject these claims was submitted with the Applicants' Request for Continued Examination (Tab F). As indicated in the final Office Action dated April 14, 2005 (Tab G), the Examiner admits that Kovacs "does not show a clear reduction to practice of a hand-held 4-cycle engine," but then states that "one of ordinary skill in the art would clearly understand that construction would involve merely miniaturization." The Examiner continues, stating that "Kovacs fails to disclose details of a lubrication system; therefore, one of ordinary skill in the art would be motivated to use the system of Takada et al for the advantages listed therein." Thus, the Examiner is combining the Kovacs reference, over which the Examiner has previously granted allowance of Claims 8-13, with Takada et al. for which the Examiner contends discloses a lubrication system in order to reject Claims 8-13.

However, independent Claim 8 does not require a lubrication system, thus making the Takada et al. an inappropriately applied reference. Instead, Claim 8 requires a frame, a handle, an implement, and a lightweight, four-cycle engine. While the Examiner is adamant that such a lubrication system would be required in such an engine, a lubrication system is not a required element of Claim 8, and to read such a limitation into Claim 8 is inappropriate. The Examiner points to no specific structural elements in the Takada et al. reference that are likewise recited in Claim 8 of the present application. Thus, the

Examiner erred in applying the Takada et al. reference to teach a lubrication system when no lubrication system is being claimed in Claim 8.

Moreover, even if a lubrication system was required, the Examiner provides no further explanation of how the combination of the lubrication system taught in Takada et al. can be combined with Kovacs to teach the portable power tool having a four-cycle engine or even that one of ordinary skill in the art would believe that they could be combined. Therefore, Applicants contend that Claim 8 remains in condition for allowance as previously determined by the Examiner because the Examiner's attempt to reject Claim 8 by combining a reference that teaches an unclaimed aspect with a reference that the Examiner has already recognized as being insufficient to teach the claimed invention is inappropriate. Applicants also assert that Claims 9-13 remain in condition for allowance for the same reasons as Claim 8 from which they depend.

3. There is No Motivation to Combine Kovacs and Takada Because the Advantage of the Takada Lubrication System Is Already Found in Kovacs

In addition to relying on an unclaimed feature, there is no need to combine the lubrication system of Takada into the Kovacs engine because the alleged benefit of the unclaimed lubrication system is already present in Kovacs. The engine disclosed by the Kovacs reference is directed to a four-cycle engine that includes a cylinder head having an inlet and outlet port located in the cylinder head and an inlet and outlet port located in the cylinder center. The Kovacs reference expressly states that "[t]he aim of the invention is to render the two-stroke engine uneconomical, firstly because the two-stroke engine has to be operated with mixture (petrol + oil)" (English translation) (Tab C, p. 3). Hence, Kovacs recognizes that a lubrication system located external from the combustion cylinder is necessary in order to allow for cleaner combustion as well as fuel savings. Contrary to the Examiner's position, Kovacs does teach a lubrication system for the four-cycle engine. The Takada et al. reference is directed to a lubrication system in which a rocker arm located above the combustion chamber is used to control the opening and closing of the inlet and outlet ports at the top of the cylinder head. The oil is transported to a rocker arm

chamber above the combustion chamber by way of an oil supply path and a return path, wherein the change in pressure in the crank chamber. The advantage taught by the Takada et al. reference is that "oil consumption can be reduce[d], while undesirable white smoke can be eliminated, even if the engine is inclined" (English translation) (Tab C, p. 7). This is the exact same benefit that already exists in Kovacs. There is simply no need to combine Kovacs and Takada.

Moreover, even if a lubrication system was required, the Examiner provides no further explanation of how the combination of the lubrication system taught in Takada et al. can be combined with Kovacs to teach the portable power tool having a four-cycle engine or even that one of ordinary skill in the art would believe that they could be combined. Therefore, Applicants contend that Claim 8 remains in condition for allowance as previously determined by the Examiner because the Examiner's attempt to reject Claim 8 by combining a reference that teaches an unclaimed aspect with a reference that the Examiner has already recognized as being insufficient to teach the claimed invention is inappropriate. Applicants also assert that Claims 9-13 remain in condition for allowance for the same reasons as Claim 8 from which they depend.

4. Examiner's Conclusion Regarding Miniaturizing the Combination of Kovacs and Takada are Improper and Unsupported

Finally, in addition to relying on an unclaimed and unneeded feature as motivation to make the Kovacs/Takada combination, the Examiner then completes the rejection of Claims 8-19 of the present application by arguing that it would have been obvious to one of ordinary skill in the art to merely miniaturize the combination of Kovacs and Takada et al. The Examiner further asserts that the reason miniaturization was never done previous to Applicants' application was only a matter of expense. However, the Examiner's purported reasoning that miniaturization was not done prior to Applicants' invention because of expense, and not technology, is not supported. The Examiner's conclusory statements by themselves are insufficient to amount to "evidence" of a motivation to combine references. *In re Kotzab*, 217 F.3d at 1370.

Contrary to the Examiner's reasoning, the scientific community recognized that miniaturization alone would not accomplish what Applicants have invented. For example, the 1993 Popular Science article titled *The Little Engine That Could* states that to characterize Ryobi's four-cycle engine as "just miniaturizing" is "an underestimate of the cleverness of the Ryobi engine design." (Tab H, p. 92).[3] Additionally, "[s]uch dramatic downsizing required smaller components; some parts, such as the valves didn't exist and had to be designed and manufactured specifically for this engine." (Tab H, p. 92). The Examiner's contention that simply miniaturizing the combination of the four-cycle engine of Kovacs and combining it and the lubrication system of Takada et al. is inapposite in view of the findings of this article. Neither Kovacs nor Takada et al. disclosed a manner in which to miniaturize the two systems, and as the article indicates, such a combination was not as simple as the Examiner contends. The Examiner has not provided a teaching or motivation to combine Takada et al. and Kovacs. Such a combination and the further miniaturization of that combination is mere speculation that is made with the benefit of hindsight only, which is improper. *In re Warner*, 379 F.2d 1011, 1017 (C.C.P.A. 1967) (stating that "[a] rejection based on section 103 clearly must rest on a factual basis... [the Patent Office] may not, because it may doubt that the invention is patentable, resort to speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in its factual basis.); *see also In re Fritch*, 972 F.2d at 1266. Thus, the Examiner has not provided a *prima facie* case of obviousness by merely asserting that it would have been obvious to one of ordinary skill in the art to miniaturize the combination of Takada et al. and Kovacs. Therefore, Applicants submit that Claims 8-19 are patentable over the prior art, and that the present apparatus is not an obvious combination of Takada et al. and Kovacs.

Further, there is no showing that the mere miniaturization of either the engine of Kovacs or the lubrication system of Takada et al. will necessarily result in a properly working engine for use on a portable, hand-held power tool.

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[3] This article refers to Ryobi because the parent application was originally assigned to Ryobi. Ryobi has since transferred all of its rights to MTD Southwest, Inc.

Without a showing that mere miniaturization would accomplish that which is taught in Claims 8-19 the Examiner's contention simply amounts to speculation. *In re Fritch*, 972 F.2d at 1265-66 (stating that the mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious to one skilled in the art unless the prior art suggested the desirability of the modification). There is no teaching as to how the four-cycle engine taught in Kovacs or the lubrication system taught in Takada et al. can be miniaturized to provide a reduction in weight and size of an engine in order to be used with a hand-held tool.

In view of the foregoing comments, Applicants respectfully submit that Claims 8-19 are patentable over Kovacs in view of Takada et al., and the claims are in a condition ready for allowance.

VIII. CONCLUSION

The cited references, either alone or in combination with the Examiner's assertions, do not provide a valid basis for a *prima facie* obviousness rejection of the present claims. Accordingly, Appellants submit that the present invention is fully patentable over Kovacs and Takada et al. and the Examiner's rejection should be REVERSED.

Respectfully submitted,

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IX. CLAIMS APPENDIX

1. (Cancelled)

2. (Cancelled)

3. (Cancelled)

4. (Cancelled)

5. (Cancelled)

6. (Cancelled)

7. (Cancelled)

8. (Previously Presented) A hand-held, portable, power tool adapted to be carried by an operator while in use, comprising:

a frame, including a handle engageable by an operator;

an implement cooperating with the frame and having a rotary-driven input member;

a lightweight, four-stroke cycle, internal combustion, spark-ignition engine attached to said frame wherein said engine comprising:

a lightweight engine block defining a cylinder head assembly, a cam housing, a crank chamber and a cylindrical bore;

an intake valve and exhaust valve in said cylinder head assembly;

a piston slidably disposed in said cylindrical bore;

a crankshaft supported by at least one bearing in said crank chamber, said crankshaft being drivably connected to said piston, and having an output end cooperating with an input end of said implement;

a cam rotatably mounted in said cam housing and driven by said crankshaft at less than the full speed of said crankshaft; and

a valve cover on said cylinder head defining a valve chamber.

9. (Previously Presented) The hand-held, portable, power tool of claim 8 wherein said tool is a line trimmer.

10. (Previously Presented) The hand-held, portable, power tool of claim 8 wherein said tool is a chain saw.

11. (Previously Presented) The hand-held, portable, power tool of claim 8 wherein said tool is a blower/vacuum.

12. (Previously Presented) The hand-held, portable, power tool of claim 8 wherein said engine further comprising:

an oil reservoir for storing engine lubrication oil; and

an engine lubrication system whereby said oil is circulated through said engine to lubricate said piston, said crankshaft, said bearing, said intake and exhaust valves, and said cam.

13. (Previously Presented) The hand-held, portable, power tool of claim 12 wherein said engine lubrication system comprising:

an oil flow passage such that said oil reservoir, said cylindrical bore, said crankshaft chamber, said cam chamber and said valve chamber are in fluid communication; and

an oil return passage from said valve chamber to said oil reservoir.

14. (Previously Presented) A hand-held, portable, power tool adapted to be carried by an operator while in use, comprising:

a frame, including a handle engageable by an operator;

an implement cooperating with the frame and having a rotary-driven input member;

a lightweight, four-stroke cycle, internal combustion, spark-ignition engine attached to said frame wherein said engine comprising:

a lightweight engine block defining a cam housing, a crank chamber and a cylindrical bore;

an intake valve and exhaust valve;

a piston slidably disposed in said cylindrical bore;

a crankshaft supported by at least one bearing in said crank chamber, said crankshaft being drivably connected to said piston, and having an output end cooperating with an input end of said implement;

a cam rotatably mounted in said cam housing and driven by said crankshaft at less than the full speed of said crankshaft.

15. (Previously Presented) The hand-held, portable, power tool of claim 14 wherein said tool is a line trimmer.

16. (Previously Presented) The hand-held, portable, power tool of claim 14 wherein said tool is a chain saw.

17. (Previously Presented) The hand-held, portable, power tool of claim 14 wherein said tool is a blower/vacuum.

18. (Previously Presented) The hand-held, portable, power tool of claim 14 wherein said engine further comprising:

an oil reservoir for storing engine lubrication oil; and

an engine lubrication system whereby said oil is circulated through said engine to lubricate said piston, said crankshaft, said bearing, said intake and exhaust valves, and said cam.

19. (Previously Presented) The hand-held, portable, power tool of claim 18 wherein said engine lubrication system comprising:

an oil flow passage such that said oil reservoir, said cylindrical bore, said crankshaft chamber, said cam chamber and said valve chamber are in fluid communication; and

an oil return passage from said valve chamber to said oil reservoir.

"Express Mail" mailing label number EH 428061513 US

Date of Deposit: September 19, 2003

Our Case No. 10512/41

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR UNITED STATES LETTERS PATENT

INVENTOR:	Robert G. Everts and Katsumi Kurihara
TITLE:	OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD
ATTORNEY:	ROBERT S. MALLIN, REG. 35,596 BRINKS HOFER GILSON & LIONE P.O. BOX 10395 CHICAGO, ILLINOIS 60610 (312) 321-4200

OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present patent document is a continuation of Serial No. 09/784,361, filed February 15, 2001, to be issued on September 23, 2003, as U.S. Patent No. 6,622,688, which is a continuation of Serial No. 09/346,750, filed July 2, 1999, now U.S. Patent No. 6,227,160, which is a continuation of Serial No. 09/028,376, filed February 24, 1998, now U.S. Patent No. 5,950,590, which is a continuation of Serial No. 08/895,345 filed July 16, 1997, now U.S. Patent No. 5,738,062, which is a continuation of Serial No. 08/651,154 filed May 21, 1996, now abandoned, which is a continuation of 08/065,576, filed May 2, 1993, now U.S. Patent No. 5,558,057, which is a continuation of Serial No. 07/801,026 filed December 2, 1991, now U.S. Patent No. 5,241,932, which are hereby incorporated by reference herein.

TECHNICAL FIELD

This invention relates to operator carried power tools and more particularly, to operator carried power told driven by a small internal combustion engine.

BACKGROUND ART

Portable operator carried power tools such as line trimmers, blower/vacuums, or chain saws are currently powered by two-cycle internal combustion engines or electric motors. With the growing concern regarding air pollution, there is increasing pressure to reduce the emissions of portable power equipment. Electric motors unfortunately have limited applications due to power availability for corded products and battery life for cordless devices. In instances where weigh is not an overriding factor such as law mowers, emissions can be dramatically reduced by utilizing heavier four-cycle engines.

When it comes to operator carried power tools such as line trimmers, chain saws and blower/vacuums, four-cycle engines pose a very difficult problem. Four-cycle engines tend to be too heavy for a given horsepower output and lubrication becomes a very serious problem since operator carried power tools must be able to run in a very wide range of orientations.

The California Resource Board (CARB) in 1990 began to discuss with the industry, particularly the Portable Power Equipment Manufacturer's Association (PPEMA), the need to reduce emissions. In responding to the CARB initiative, the PPEMA conducted a study to evaluate the magnitude of emissions generated by two-cycle engines in an effort to determine whether they were capable of meeting the proposed preliminary CARB standards tentatively scheduled to go into effect in 1994. The PPEMA study concluded that at the present time, there was no alternative power source to replace the versatile lightweight two-stroke engine currently used in hand held products. Four-cycle engines could only be used in limited situations, such as in portable wheeled products like lawn mowers or generators, where the weight of the engine did not have to be borne by the operator.

It is an object of the present invention to provide a hand held powered tool which is powered by an internal combustion engine having low emissions and is sufficiently light to be carried by an operator.

It is a further object of the present invention to provide a portable hand held powered tool powered by a small internal combustion engine having an internal lubrication system enabling the engine to be run at a wide variety of orientations typically encountered during normal operation.

It is a further object of the present invention to provide a portable power tool to be carried by an operator which is driven by a small lightweight four-cycle engine having an aluminum engine block, an overhead valve train and a splasher lubrication system for generating an oil mist to lubricate the crank case throughout the normal range of operating positions.

It is yet a further object of the invention to provide an oil mist pumping system to pump an oil mist generated in the crank case into the overhead valve chamber.

These objects and other features and advantages of the present invention will be apparent upon further review of the remainder of the specification and the drawings.

DISCLOSURE OF THE INVENTION

Accordingly, a portable hand held power tool of the present invention intended to be carried by an operator is provided utilizing a small four-cycle internal combustion engine as a power source. The four-cycle engine is mounted on a frame to be carried by an operator during normal use. The tool has an implement cooperating with the frame having a rotary driven input member coupled to the crankshaft of the four-cycle engine. The four-cycle engine is provided with a lightweight aluminum engine block having at least one cylindrical bore oriented in a normally upright orientation having an enclosed oil reservoir located therebelow. A crankshaft is pivotably mounted within the engine block. The enclosed oil reservoir when properly filled, enables the engine to rotate at least 30 degrees about the crankshaft axis in either direction without oil within the reservoir rising above the level of the crankshaft counter weight. A splasher is provided to intermittently engage the oil within the oil reservoir to generate a mist to lubricate the engine crank case.

One embodiment of the invention pumps an oil mist from the crank case to an overhead valve chamber to lubricate the valve train.

In yet another embodiment of the invention, the overhead valve chamber is sealed and is provided with a lubrication system independent of the crank case splasher system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view illustrating a line trimmer of the present invention;

Figure 2 is a cross-sectional side elevation of the engine taken along line 2.2 of Figure 1;

Figure 3 is a side cross-sectional elevational view of the engine of Figure 2;

Figure 4 is an enlarged schematic illustration of the camshaft and the follower mechanism;

Figure 5 is a cross-sectional side elevational view of a second engine embodiment;

Figure 6 is a cross-sectional end view illustrating the valve train of the second engine embodiment of Figure 5;

Figure 7 is a cross-sectional side view of a third engine embodiment;

Figure 8 is an enlarged cross-sectional view of the third engine embodiment of Figure 7 illustrating the lubrication system;

Figure 9 is a partial cross-sectional end view of the third engine embodiment shown in Figures 7 and 8 further illustrating the lubrication system;

Figure 10 is a timing diagonal of the lubrication system of the third engine embodiment;

Figure 11 is a torque versus RPM curve; and

Figure 12 and Figure 13 contrast the pull force of a four and a two-cycle engine.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 1 illustrates a line trimmer 20 made in accordance with the present invention. Line trimmer 20 is used for illustration purposes and it should be appreciated that other hand held power tools tended to be carried by operators such as chain saws or a blower vacuum can be made in a similar fashion. Line trimmer 20 has a frame 22 which is provided by an

elongated aluminum tube. Frame 22 has a pair of handles 24 and 26 to be grasped by the operator during normal use. Strap 28 is placed over the shoulder of the user in a conventional manner in order to more conveniently carry the weight of the line trimmer during use. Attached to one end of the frame generally behind the operator is a four-cycle engine 30. The engine drives a conventional flexible shaft which extends through the center of the tubular frame to drive an implement 32 having a rotary cutting head or the like affixed to the opposite end of the frame. It should be appreciated that in the case of a chain saw or a blower/vacuum, the implement would be a cutting chain or a rotary impeller, respectively.

Figure 2 illustrates a cross-sectional end view of a four-cycle engine 30. Four-cycle engine 30 is made up of a lightweight aluminum housing including an engine block 32 having a cylindrical bore 34 formed therein. Crankshaft 36 is pivotably mounted within the engine block in a conventional manner. Piston 38 slides within a cylindrical bore 34 and is connected to the crankshaft by connecting rod 40. A cylinder head 42 is affixed to the engine block to define an enclosed combustion chamber 44. Cylinder head 42 is provided with intake port 46 coupled to a carburetor 48 and selectively connected to the combustion chamber 44 by intake valve 50. Cylinder head 42 is also provided with an exhaust port 52 connected to muffler 54 and selectively connected to combustion chamber 44 by exhaust valve 56.

As illustrated in Figures 2 and 3, the cylinder axis of four-cycle engine 30 is generally upright when in normal use. Engine block 32 is part of a housing portion that provides an enclosed oil reservoir 58. The reservoir is relatively deep so that there is ample clearance between the crankshaft and the level of the oil during normal use. As illustrated in Figure 2, the engine may be rotated about the crankshaft axis plus or minus at angle $\exists$ before the oil level would rise sufficiently to contact the crankshaft. Preferably, $\exists$ is at least above 30° and most preferably at least 45° in order to avoid excessive interference between the crankshaft and the oil within the oil reservoir. As

illustrated in a cross-sectional side elevation shown in Figure 3, the engine shown in its vertical orientation would typically be used in a line trimmer canted forward 20° to 30°. As illustrated, the engine can be tipped fore and aft plus or minus an angle ∀ without the oil within the reservoir striking the crankshaft. Again, preferably the angle ∀ is at least above 20° viewing the engine in side view along the transverse axis orthogonal to the axes of the engine crankshaft 36 and the cylinder bore 34.

In order to lubricate the engine, connecting rod 40 is provided with an oil mist generator or splasher portion 60 which dips into and agitates the oil within the reservoir with each crankshaft revolution. The splasher 60 is an oil mist generator that creates, as it is driven by the piston-connecting rod-crankshaft assembly, an oil mist which lubricates the internal moving parts within the engine block.

As illustrated in Figure 3, the crankshaft 36 is of a cantilever design similar to that commonly used by small two-cycle engines. The crankshaft is provided with an axial shaft member 62 having an output end 64 adapted to be coupled to the implement input member and input end 66 coupled to a counterweight 68. A crankpin 70 is affixed to counterweight 68 and is parallel to and radially offset from the axial shaft 62. Crankpin 70 pivotally cooperates with a series of roller bearings 72 mounted in connecting rod 40. The axial shaft 62 of crankshaft 36 is pivotably attached to the engine block 32 by a pair of conventional bearings 74 and 76. Intermediate bearings 74 and 76 is camshaft drive gear 78.

The camshaft drive and valve lifter mechanism is best illustrated with reference to Figures 3 and 4. Drive gear 78 which is mounted upon the crankshaft drives cam gear 80 which is twice the diameter resulting in the camshaft rotating in one-half engine speed. Cam gear 80 is affixed to the camshaft assembly 82 which is journaled to engine block 32 and includes a rotary cam lobe 84. In the embodiment illustrated, a single cam lobe is utilized for driving both the intake and exhaust valves. However, a

conventional dual cam system could be utilized as well. Cam lobe 84, as illustrated in Figure 4, operates intake valve follower 86 and intake push rod 88 as well as exhaust valve follower 90 and exhaust push rod 92. Followers 86 and 90 are pivotably connected to the engine block by pivot pin 93. Push rods 88 and 92 extend between camshaft followers 86 and 90 and rocker arms 94 and 96 located within the cylinder head 42. The cam push rods and rocker arms are part of a valve train assembly. Affixed to the cylinder head 42 is a valve cover 98 which defines therebetween enclosed valve chamber 100 which defines therebetween enclosed valve chamber 100. A pair of push rod tubes 102 surround the intake and exhaust push rods 88 and 92 in a conventional manner in order to prevent the entry of dirt into the engine. In the embodiment of the invention illustrated, four-cycle engine 30 has a sealed valve chamber 100 which is isolated from the engine block and provided with its own lubricant. Preferably, valve chamber 100 is partially filled with a lightweight moly grease. Conventional valve stem seals, not shown, are provided in order to prevent escape of lubricant.

Engine 30 operates on a conventional four-cycle mode. Spark plug 104 is installed in a spark plug hole formed in the cylinder head so as to project into enclosed combustion chamber 44. The intake charge provided by carburetor 48 will preferably have an air fuel ration which is slightly lean stoichiometric; i.e., having an air fuel ratio expressed in terms of stoichiometric ration which is not less than 1.0. It is important to prevent the engine from being operated rich so as to avoid a formation of excessive amount of hydrocarbon (HC) and carbon monoxide (CO) emissions. Most preferably, the engine will operate during normal load conditions slightly lean of stoichiometric in order to minimize the formation of HC, CO and oxides of nitrogen (NOx). Running slightly lean of stoichiometric air fuel ratio will enable excess oxygen to be present in the exhaust gas thereby fostering post-combustion reduction of hydrocarbons within the muffler and exhaust port.

For use in a line trimmer of the type illustrated in Figure 1, adequate power output of a small lightweight four-cycle engine is achievable utilizing an engine with a displacement less than 50 cc. Preferably, engines for use in the present invention will have a displacement falling within the range of 20 and 40 cc. Engines of displacement larger than 50 cc will result in excessive weight to be carried by an operator. Engines of smaller displacement will have inadequate power if operated in such a manner to maintain low emission levels.

In order to achieve high power output and relatively low exhaust emissions, four-cycle engine 30 is provided with a very compact combustion chamber 44 having a relatively low surface to volume ration. In order to maximize volumetric efficiency and engine output for relatively small engine displacement, canted valves shown in Figure 2 are used resulting in what is commonly referred to as a hemispherical-type chamber. Intake and exhaust ports 46 and 52 are oriented in line and opposite one another resulting in a cross flow design capable of achieving very high horsepower relative to engine displacement compared to a typical four-cycle lawn mower engine having a flat head and a valve-in-block design.

A second engine embodiment 110 is illustrated in Figures 5 and 6. Engine 110 is very similar to engine 30 described with reference to Figures 2-4 except for the valve train and lubrication system design. Engine 110 is provided with a camshaft 112 having a pair of cam lobes, intake cam lobes 114 and exhaust cam lobes 116 affixed to the camshaft and at axially spaced apart orientation. Camshaft 112 is further provided with a cam gear 118 cooperating with a drive gear affixed to the crankshaft as previously described with reference to the first engine embodiment 30. Intake and exhaust followers 120 and 122 are slidably connected to the engine block and are perpendicular to the axis of the camshaft in a conventional manner. Intake and exhaust followers 120 and 122 reciprocally drive intake and exhaust push rods 124 and 126.

Engine 110 also differs from engine 30 previously described in the area of cylinder head lubrication. Cylinder head 128 and valve cover 130 define therebetween an enclosed valve chamber 132. Valve chamber 132 is coupled to oil reservoir 134 by intake and exhaust push rod guide tubes 136 and 138. Valve cover 130 is further provided with a porous breather 140 formed of a sponge-like or sintered metal material. As the piston reciprocates within the bore, the pressure within the oil reservoir will fluctuate. When the pressure increases, mist-laden air will be forced through the valve guide tubes into the valve chamber 132. When the piston rises, the pressure within the oil reservoir 134 will drop below atmospheric pressure causing air to be drawn into the engine breather 140. The circulation of mist-laden air between the engine oil reservoir and the valve chamber will supply lubrication to the valves and rocker arms. By forming the breather of a porous material, the escape of oil and the entry of foreign debris will be substantially prohibited.

Figures 7-10 illustrate a third engine embodiment 150 having yet a third system for lubricating overhead valves. Engine 150 has an engine block with a single cam and dual follower design generally similar to that of Figures 2 and 3 described previously. Cylinder head 152 is provided with a valve cover 154 to define enclosed valve chamber 156 therebetween. Valve chamber 156 is coupled to oil reservoir 158 within the engine block. In order to include the mist-laden air within the oil reservoir 158 to circulate through valve chamber 156, flow control means is provided for alternatively selectively coupling the valve chamber to the oil reservoir via one of a pair of independent fluid passageways.

As illustrated in Figures 8 and 9, intake push rod tube 160 provides a first passageway connecting the oil reservoir to the valve chamber, while exhaust push rod tube 162 provides a second independent passageway connecting the valve chamber 156 to the oil reservoir 158. As illustrated in Figure 8, port B connects push rode tube 162 to the cylindrical bore 166. Port B intersects the cylindrical bore at a location which is swept by the skirt

of piston 168 so that the port is alternatively opened and closed in response to piston movement. Camshaft 170 is pivotally mounted on a hollow tubular shaft 172. Camshaft 170 and support shaft 172 are each provided with a pair of ports A which are selectively coupled and uncoupled once every engine revolution, i.e., twice every camshaft revolution. When the ports are aligned, the oil reservoir is fluidly coupled to the valve chamber via the intake push rod tube 162. When the ports are misaligned, the flow path is blocked.

Figure 10 schematically illustrates the open and close relationship of the A and B ports relative to crankcase pressure. When the piston is down and the crankcase is pressurized, the A port is open allowing mist-laden air to flow through the passageway within camshaft support shaft 172 through the intake push rod tube 160 and into the valve chamber 156. When the piston rises, the crankcase pressure drops below atmospheric pressure. When the piston is raised, the A port is closed and the B port is opened enabling the pressurized air from valve chamber 156 to return to oil reservoir 158.

Of course, other means for inducing the circulation of mist-laden air from the oil reservoir to the valve chamber can be used to obtain the same function, such as check valves or alternative mechanically operated valve designs. Having a loop type flow path as opposed to a single bi-directional flow path, as in the case of the second engine embodiment 110, more dependable supply of oil can be delivered to the valve chamber.

It is believed that small lightweight four-cycle engines made in accordance with the present invention will be particularly suited to use with rotary line trimmers, as illustrated in Figure 1. Rotary line trimmers are typically directly driven. It is therefore desirable to have an engine with a torque peak in the 7000 to 9000 RPM range which is the range in which common line trimmers most efficiently cut. As illustrated in Figure 11, a small four-cycle engine of the present invention can be easily tuned to have a torque peak corresponding to the optimum cutting speed of a line trimmer head. This enables smaller horsepower engine to be utilized to achieve the

same cutting performance as compared to a higher horse power two-cycle engine which is direct drive operated. Of course, a two-cycle engine speed can be matched to the optimum performance speed of the cutting head by using a gear reduction. However, this unnecessarily adds cost, weight and complexity to a line trimmer.

Another advantage to the four-cycle engine for use in a line trimmer is illustrated with reference to Figures 12 and 13. Figure 12 plots the starter rope pull force versus engine revolutions. The force pulses occur every other revolution due to the four-cycle nature of the engine. A two-cycle engine as illustrated in Figure 13 has force pulses every revolution. It is therefore much easier to pull start a four-cycle engine to reach a specific starting RPM since approximately half of the work needs to be expended by the operator. Since every other revolution of a four-cycle engine constitutes a pumping loop where there is relatively little cylinder pressure, the operator pulling starter rope handle 174 (shown in Figure 1) is able to increase engine angular velocity during the pumping revolution so that proper starting speed and sufficient engine momentum can be more easily achieved. The pull starter mechanism utilized with the four-cycle engine is of a conventional design. Preferably, the pull starter will be located on the side of the engine closest to the handle in order to reduce the axial spacing between trimmer handle 24 and the starter rope handle 174, thereby minimizing the momentum exerted on the line trimmer during startup. A four-cycle engine is particularly advantageous in line trimmers where in the event the engine were to be shut off when the operator is carrying the trimmer, the operator can simply restart the engine by pulling the rope handle 174 with one hand and holding the trimmer handle 24 with the other. The reduced pull force makes it relatively easy to restart the engine without placing the trimmer on the ground or restraining the cutting head, as is frequently done with two-cycle line trimmers.

It should be understood, of course, that while preferred embodiments of the invention have been shown and described herein, it is not intended to illustrate all possible variations thereof. Alternative structures may be created by one of ordinary skill in the art without departing from the spirit and scope of the invention as set forth in the following claims.

CLAIMS

1. A lubrication method for lubricating a lightweight, four-stroke cycle, throttle-controlled, internal combustion engine used with a power tool to be carried by an operator when in use, the engine having an engine block, a reciprocating piston in a cylinder in the engine block, a crankshaft, at least one bearing supporting said crankshaft, a cam, a cam gear, a valve train, a pair of rocker arms, an oil reservoir and a cylinder head defining an intake and exhaust valve chamber and overhead intake and exhaust valves, the method comprising the steps of:

creating within said oil reservoir a lubrication oil mist;

providing said oil mist to said piston, said crankshaft, said bearing, said cam, said cam gear, said valve train, said pair of rocker arms, and said overhead intake and exhaust valves by conducting the oil mist through a passage from said reservoir to the valve chamber; and

conducting the oil mist in a return flow passage through said engine block from said valve chamber to said reservoir.

2. A hand-held, portable, power tool adapted to be carried by an operator while in use, comprising:

a frame, including a handle engageable by an operator;

an implement cooperating with the frame and having a rotary-driven input member;

a lightweight, four-stroke cycle, internal combustion, spark-ignition engine attached to said frame wherein said engine comprising:

a lightweight aluminum engine block defining a cylinder head assembly, a cam housing, a crank chamber and a cylindrical bore;

an intake valve and exhaust valve in said cylinder head assembly;

a piston slidably disposed in said cylindrical bore;

a crankshaft supported by at least one bearing in said crank chamber, said crankshaft being drivably connected to said piston, and having an output end cooperating with an input end of said implement;

a cam rotatably mounted in said cam chamber and driven by said crankshaft at less than the full speed of said crankshaft; and

a valve cover on said cylinder head defining a valve chamber.

3. The hand-held, portable, power tool of claim 2 wherein said tool is a line trimmer.

4. The hand-held, portable, power tool of claim 2 wherein said tool is a chain saw.

5. The hand-held, portable, power tool of claim 2 wherein said tool is a blower/vacuum.

6. The hand-held, portable, power tool of claim 2 wherein said engine further comprising:

an oil reservoir for storing engine lubrication oil; and

an engine lubrication system whereby said oil is circulated through said engine to lubricate said piston, said crankshaft, said bearing, said intake and exhaust valves, and said cam.

7. The hand-held, portable, power tool of claim 6 wherein said engine lubrication system comprising:

an oil flow passage such that said oil reservoir, said cylindrical bore, said crankshaft chamber, said cam chamber and said valve chamber are in fluid communication; and

an oil return passage from said valve chamber to said oil reservoir.

Abstract

An engine powered hand-held power tool and engine lubrication method is provided, the power tool being intended to be carried by an operator during use. The power tool has a frame, including a handle to be grasped by the operator, an implement affixed to the frame having a rotary input member, and a small four-cycle, lightweight, internal combustion engine attached to the frame for driving the implement. The four-cycle engine has a lightweight aluminum alloy engine block having a cylindrical bore and an enclosed oil reservoir formed therein. A crankshaft is rotatably mounted in the engine block for rotation about a crankshaft axis. A piston reciprocates within the bore and is connected to the crankshaft by a connecting rod. An oil splasher driven by the crankshaft intermittently engages the oil within the enclosed oil reservoir to splash-lubricate the engine. The engine is provided with a cylinder head assembly defining a compact combustion chamber having a pair of overhead intake and exhaust ports and cooperating intake and exhaust valves. A lightweight, high-powered engine is thereby provided having relatively low HC and CO emissions.

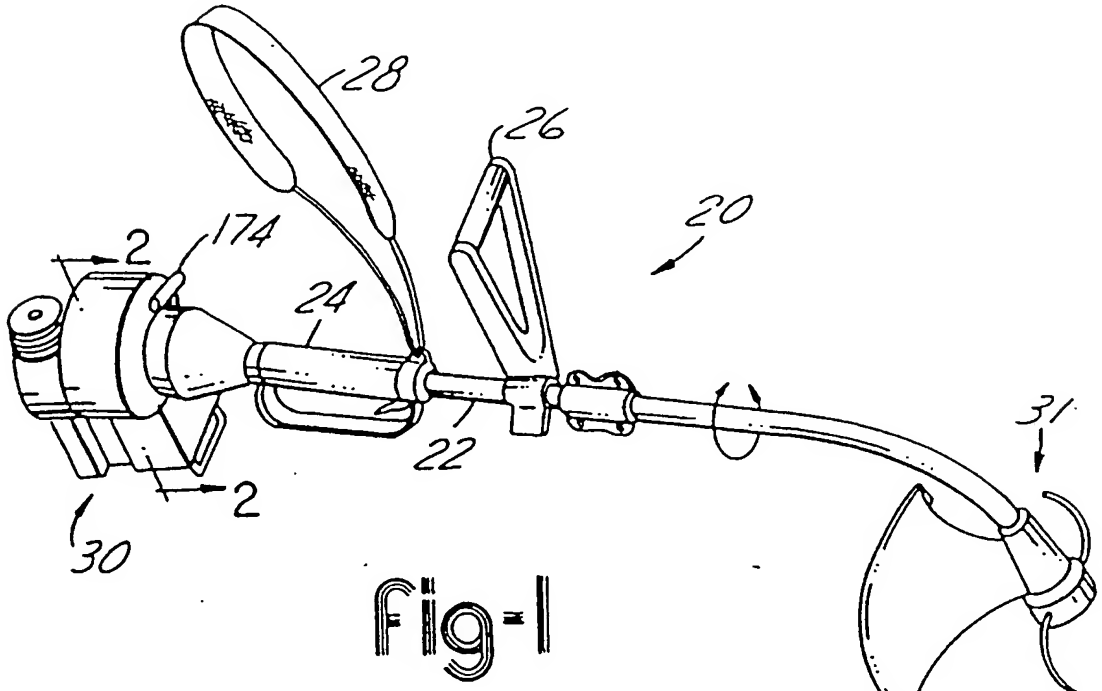
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fig-1

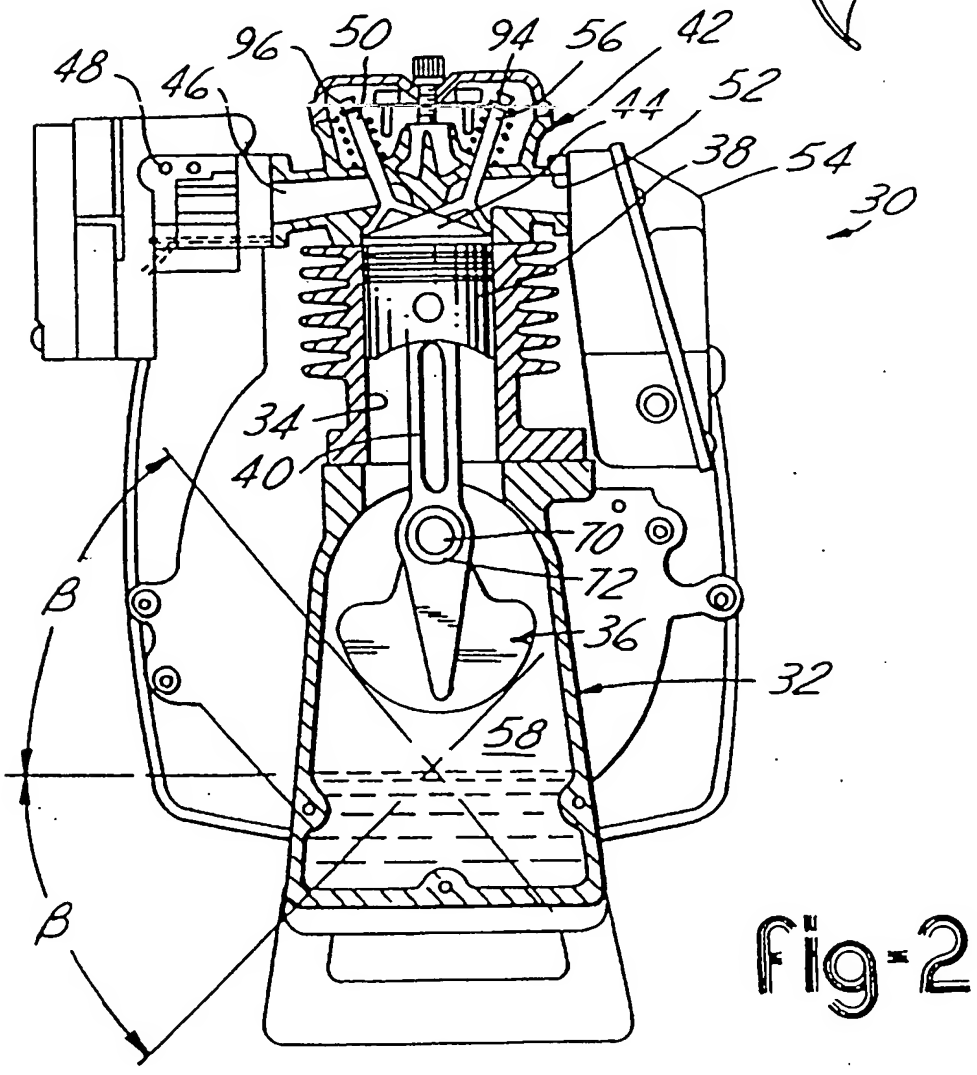
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fig-2

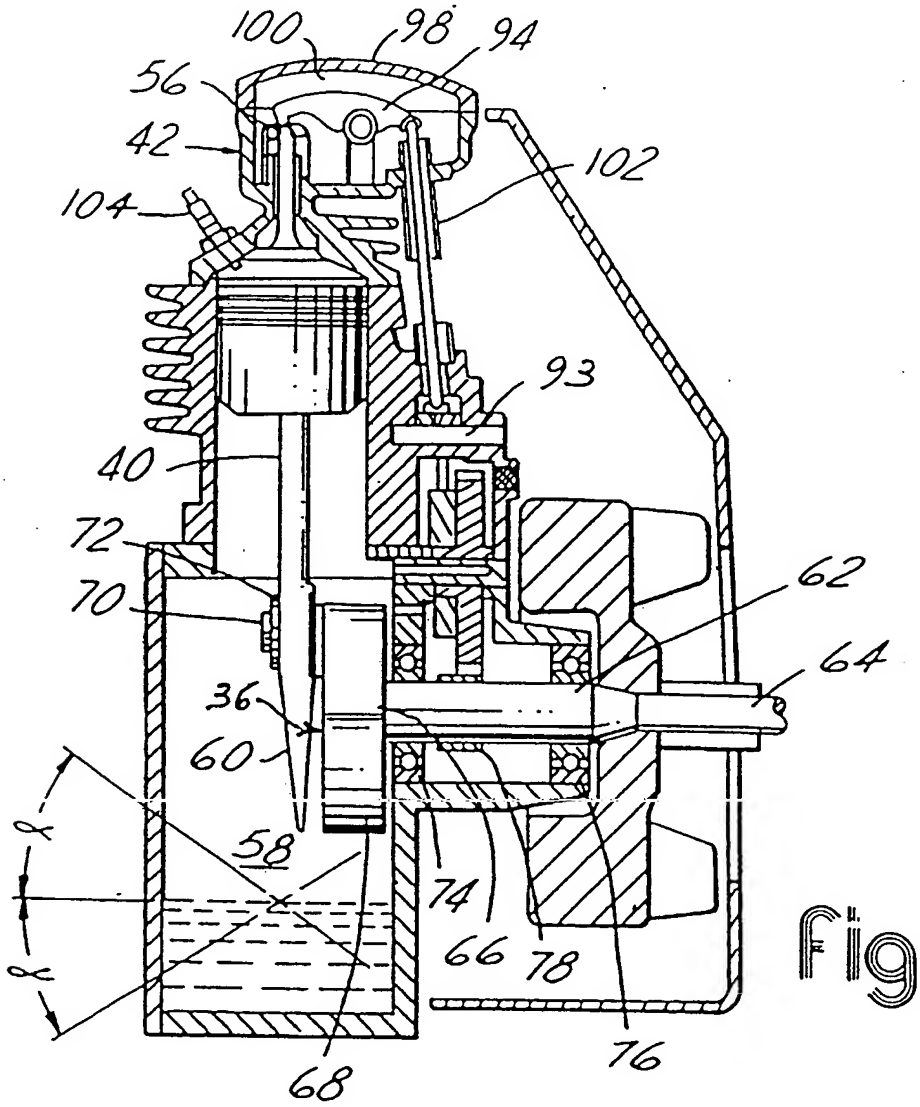
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fig-3

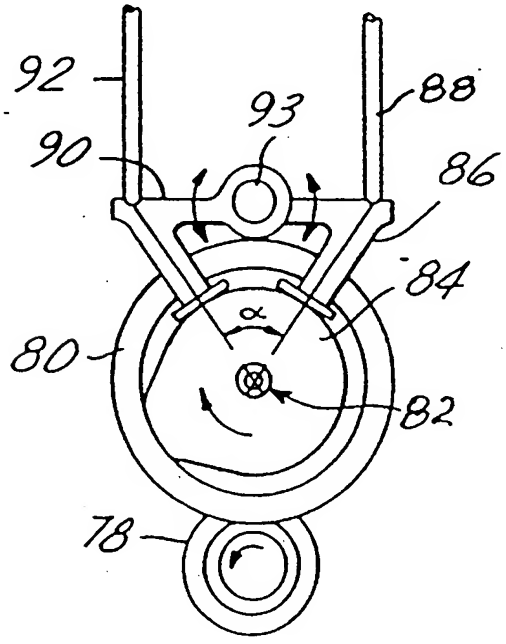
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fig-4

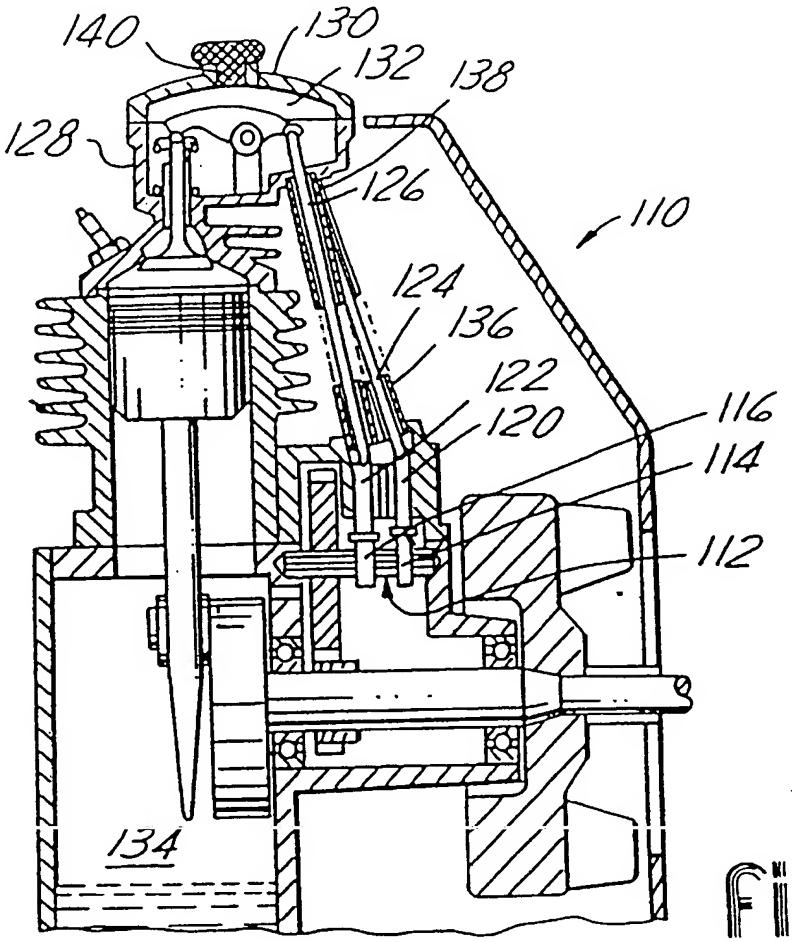
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Fig-5

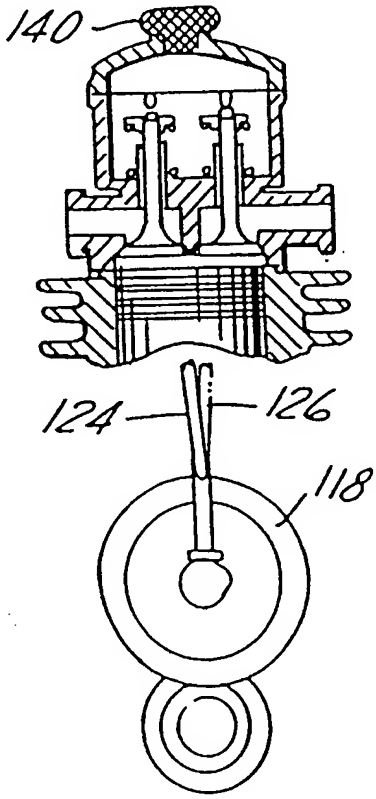
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Fig-6

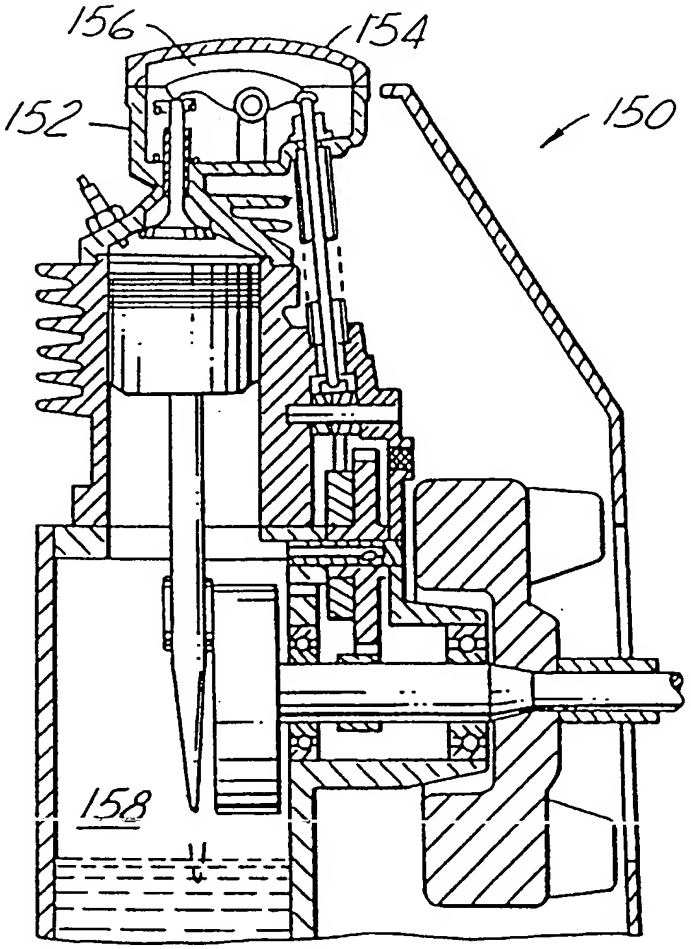


Fig-7

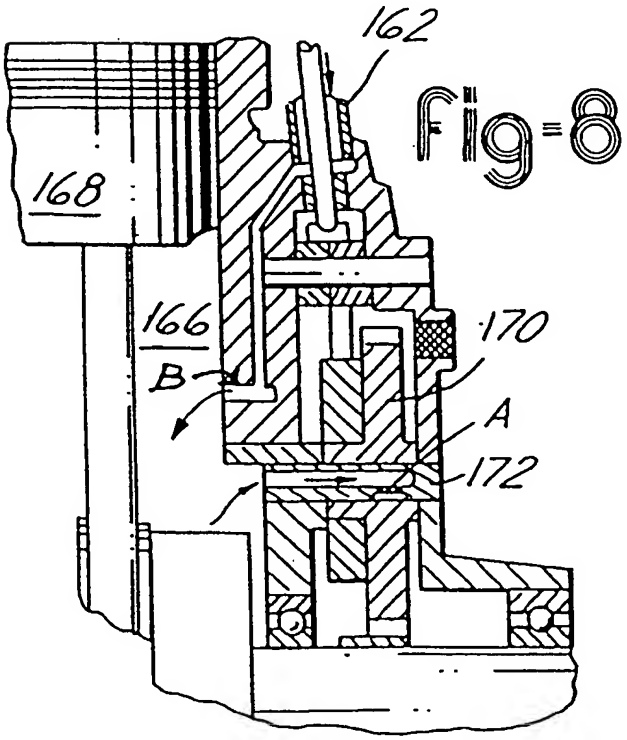
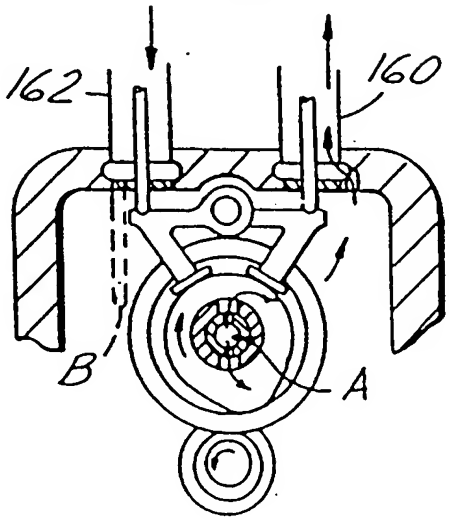


Fig-8

Fig-9



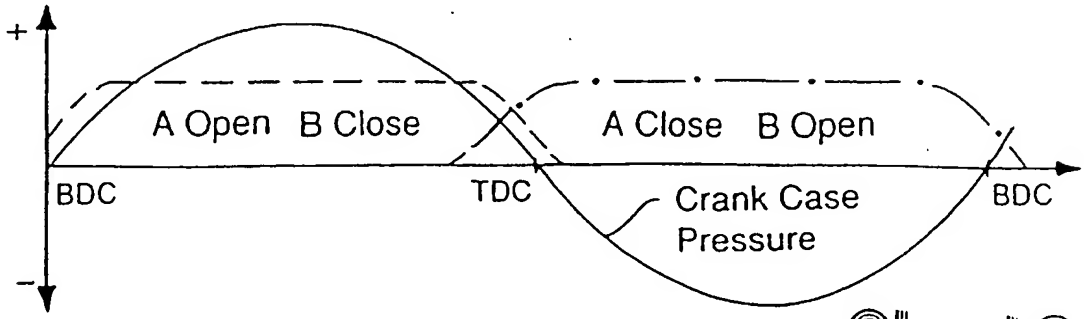


Fig-10

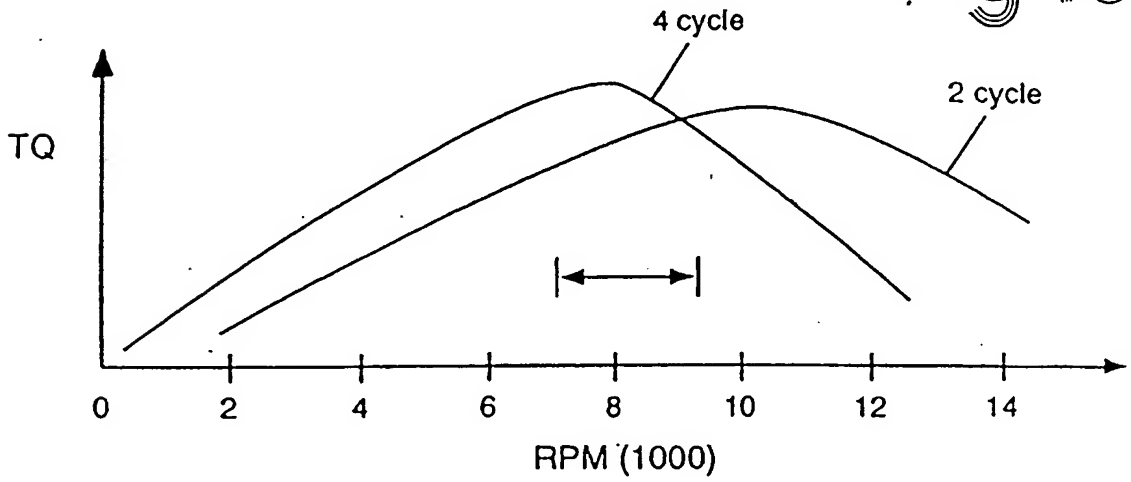


Fig-11

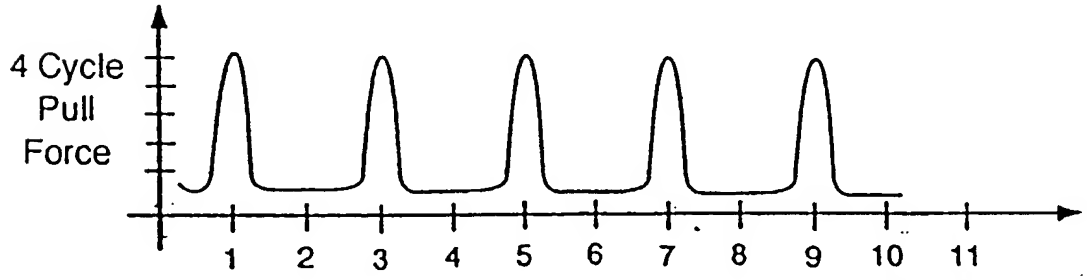


Fig-12

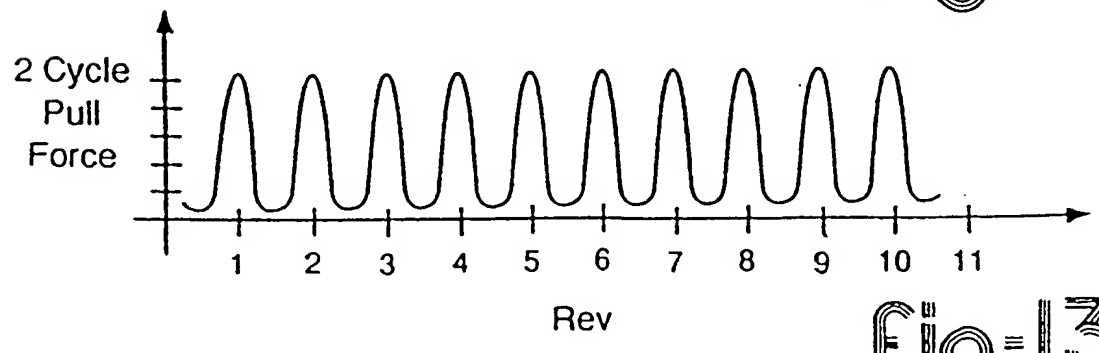


Fig-13

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DE 3335962 A1

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(72) Erfinder:
gleich Anmelder

(54) Viertaktmotor (Kovacs Motor)

DE 3335962 A1

01. Innenverbrennungsmotor (Explosionsmotor) mit vier Arbeitstakten, dadurch gekennzeichnet, daß diese Motor am Zilinderkopf und am Zilinderwand Einlass, und Auslasskanäle hatt.

Der [redacted] Viertaktmotor ist für jeden Kraftstoff geeignet.

Der [redacted] Viertaktmotor zeichnet sich durch einen niedrigen Kraftstoffverbrauch, und ,eine hohe Umweltfreundlichkeit aus.

3335962

Viertaktmotor (~~Kreuz-Motor~~)

Die Erfindung betrifft einen Hubkolbenmotor mit vier Arbeitstakten und eignet sich hauptsächlich für den Antrieb von Motorräder, Kreinkrafträder, Rasenmäher, Kettensäge, Geräte, Pumpen, usw.

Zweck der Erfindung ist den Zweitaktmotor Unrentabel zu machen, erstens wegen der zustand, daß der Zweitaktmotor mit mischung Betrieben werde, (Benzin + Oel) zweitens wegen der hohen Verbrauch, und drittens wegen der hohen Umweltverschmutzung.
Dies geschiet dadurch, erstens daß diese Viertaktmotor mit reines Kraftstoff Betrieben werde. Hauptsächlich aber dadurch, daß bei diese Motor der Verbrennungsraum nach jedem Arbeitstakt auf das optimalste entlehrt werde.

Der Zweitaktmotor entlehrt den Verbrennungsraum dadurch, daß die frische Gase aus der Kurbelgeheuse durch die durchlasskanäle in dem Verbrennungsraum gelangt, und die verbranten Gase hinausdrückt. Dieses forgang ist sehr unvollständig. Dies kann durch tuning verbessert werden. Allerdings das dadurch erreichte ist nicht das optimale.

Der Erfindung liegt die Aufgabe zugrunde, den Verbrennungsraum soweit zu entleren wie es nur möglich ist.

Diese Aufgabe werde erfindungsgemäß in folgender weise gelöst:
Der Motor werde mit eine Einlassventill und eine Auslassventill in dem Zilinderkopf gebaut,und eine Auslasskanal zusätzlich das geöffnet ist wenn der Kolben am unteren totenpunkt angekommen ist.(Genau wie das Auspuffkanal eines Zweitaktmotors)
Ebenfalls zwei öfnunge als einlassöffnung. (Genau wie der Durchlasskanal der Zweitaktmotore in das Zilinder münde)
Auspuffkanal am Zilinderkopf und am Zilindermitte münden zusammen.
Einlasskanal am Zilinderkopf und am Zilindermitte münden in eine Gebläse.
Die Arbeitsweise werde folgender maße Verrichtet:

2.

Wenn der Kolben am unteren totenpunkt angelangt ist, werde durch das untere Einlassöffnung luft in das Zilinder hineingeschoben. Diese menge luft ermöglicht eine reinigung des Zilinders entsprechend des Zweitaktmotors. Durch das weitere drehung des Motors bewegt sich der Kolben nach oben, und werde das Auspuffventill geöffnet und die verdünnte restauspuffgase werden mit entsprechende menge frischluft sweitesmahl hinausgeschoben. Jetzt werde der Einlassventill geöffnet, und wehrend der Kolben sich nach unten bewegt, strömt luft in das Zilinder. In den bereich des Auspuffkanals strömt sogar luft hinaus, verstärkt die einströmenge luft das durch den einlasskanal am unteren ende des Zilinders hinein strömt.
Auf diese weise werde das Zilinder follständig von sämtlichen verbranten Gase gereinigt. An der stand als der Kolben am unteren totenpunkt angekommen ist, werde der Einlassventill geschlossen. Jetzt bewegt sich der Kolben nach oben, und nach dehm das untere Auslasskanal geschlossen ist werde Kraftstoff eingespritzt. Von das art des Kraftstoffes abhängig werde nach erfolgtem Verdichten gezündet, oder zündet sich selbst.

Die erzielbaren Vorteile des [redacted] Viertaktmotors liegen darin, daß durch die optimalste Reinheit des Luft-Gasgemisches die im Kraftstoff enthaltene Energie ebenfalls auf das optimalste genützt werden kann. Weiterhin entstäht die sauberste Verbrennung und damit eine Umweltfreundlichkeit, die man sich nur wünschen kann. Die Kraftstoffersparniss wird auf über 50% geschätzt.

Auf ein Ausführungsbeispiel wird verzichtet. Die beschreibung alleine muss für einen Fachmann genügen eine [redacted] Viertaktmotor zu bauen.

(B6) English translation

GERMAN OFFENLEGUNGSSCHRIFT DE 33 35 962 A1

Application date: 04.10.83
Publication date: 02.05.85
Applicant: Kovacs, Emil

Four-stroke engine (Kovacs Engine)

1. Internal-combustion engine with four working cycles, characterised in that this engine has inlet and outlet ports in the cylinder head and in the cylinder wall.

The four-stroke engine is suitable for any fuel.

The four-stroke engine is characterised by low fuel consumption and is environmentally friendly to a high degree.

The invention relates to a reciprocating piston engine with four working cycles and is mainly suitable for the propulsion of motorcycles, small motorcycles, lawn mowers, chain saws, appliances, pumps, etc.

The aim of the invention is to render the two-stroke engine uneconomical, firstly because the two-stroke engine has to be operated with mixture (petrol + oil), secondly because of its high consumption and, thirdly, because of its high level of pollution. This is achieved firstly in that this four-stroke engine is operated with pure fuel but, principally, in that in this engine the combustion chamber is exhausted in optimum manner after each working cycle.

In a two-stroke engine the combustion chamber is exhausted in that the fresh gases are discharged from the crankcase through the ports into the combustion chamber and thereby expels the combusted gases. This process is very incomplete. It can be improved by tuning but, in any case, the results obtained are not the optimum.

The invention is based on the object of exhausting the combustion chamber to the greatest possible extent.

According to the invention, this object is achieved in the following manner:

The engine is built with an inlet valve and an outlet valve in the cylinder head, and an outlet port is additionally opened when the piston reaches bottom dead centre. (Exactly like the exhaust port of a two-stroke engine). Likewise two openings as inlet opening. (Exactly how the port of the two-stroke engine discharges into the cylinder). The exhaust port in the cylinder head and in the cylinder centre discharge together. The inlet port in the cylinder head and in the cylinder centre discharge into a blower.

The mode of operation is as follows:

When the piston reaches bottom dead centre, air is forced into the cylinder through the lower inlet opening. This quantity of air enables the cylinder to be purged in a manner corresponding to a two-stroke engine. Upon further rotation of the engine the piston moves upwards and the exhaust valve is

opened and the diluted residual exhaust gases are expelled twice with a corresponding quantity of fresh air. Then the inlet valve is opened and air flows into the cylinder while the piston moves downwards. Air even flows out in the vicinity of the exhaust port and boosts the inflowing air which enters through the inlet port at the lower end of the cylinder.

In this way the cylinder is completely purged of all combusted gases. The inlet valve is closed at the instant that the piston reaches bottom dead centre. The piston then moves upwards and fuel is injected after the lower outlet port is closed. Depending on the nature of the fuel, ignition takes place after compression has occurred or it ignites itself.

The advantages which can be achieved with the four-stroke engine are that as a result of the optimum purity of the air-gas mixture the energy contained in the fuel can also be utilised in optimum fashion. Moreover, combustion is extremely clean and is environmentally friendly to a desirable extent. The fuel saving is estimated to be above 50 %.

No example of embodiment is provided. The description by itself should be sufficient for a person skilled in the art to construct a four-stroke engine.

E5

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　昭61－39416

⑤1Int.Cl.⁴	識別記号	庁内整理番号	㊸公開　昭和61年(1986)3月12日
F 01 M 9/10		6941－3G	
9/06		6941－3G	

審査請求　未請求　（全2頁）

⑤4考案の名称　ロツカーアーム室の給油装置

㉑実　願　昭59－124834
㉒出　願　昭59(1984)8月16日

㉒考案者　高田　敏之　明石市川崎町1番1号　川崎重工業株式会社明石工場内
㉒考案者　三沢　吉次　明石市川崎町1番1号　川崎重工業株式会社明石工場内
㉑出願人　川崎重工業株式会社　神戸市中央区東川崎町3丁目1番1号
㉔代理人　弁理士　大音　康毅

⑤7実用新案登録請求の範囲

(1) クランク室内のオイルを送油通路および戻り通路を通してロツカアーム室へ循環させる給油装置において、前記戻り通路のクランク室側をタペットの動きにより開閉可能にし、クランク室が負圧のとき該タペットにより前記戻り通路を開き負圧でオイルの戻りを助勢するよう構成して成るロツカーアーム室の給油装置。

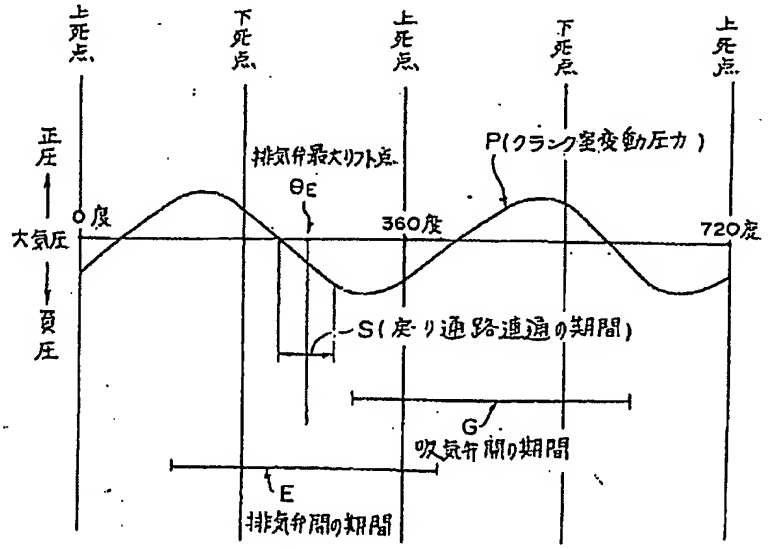
(2) 送油通路にクランク室からロツカアーム室へ向うオイルの流れを許す逆止弁を設けることを特徴とする実用新案登録請求の範囲第1項記載のロツカーアーム室の給油装置。

図面の簡単な説明

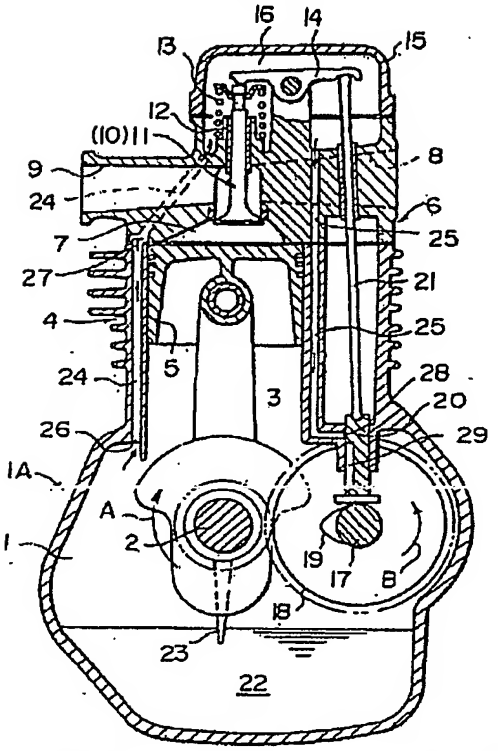
第1図は本考案の一実施例に係るロツカアーム室の給油装置を備えた頭上弁式エンジンの縦断面図、第2図は第1図のタペットの動きによる戻り通路の連通タイミングSとクランク室変動圧力Pとの関係を例示するグラフである。

1…クランク室、16…ロツカーアーム室、17…カム軸、20…タペツド、21…プッシユロツド、22…オイル、24…送油通路、25…戻り通路、27…逆止弁、29…蓋。

第2図



第1図



1---クランク室　22---オイル　27---逆止弁
16---ロッカーアーム室　24---送油通路　29---溝
20---タペット　25---戻り通路

公開実用 昭和61－39416

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　昭61－39416

⑤1Int.Cl.⁴	識別記号	庁内整理番号	④3公開 昭和61年(1986)3月12日
F 01 M 9/10		6941－3G	
9/06		6941－3G	

審査請求 未請求 （全 頁）

⑤4考案の名称　ロツカーアーム室の給油装置

⑵1実　願 昭59－124834

⑵2出　願 昭59(1984)8月16日

⑦2考 案 者　高田　敏之　明石市川崎町1番1号　川崎重工業株式会社明石工場内

⑦4考 案 者　三沢　吉次　明石市川崎町1番1号　川崎重工業株式会社明石工場内

⑦1出 願 人　川崎重工業株式会社　神戸市中央区東川崎町3丁目1番1号

⑦4代 理 人　弁理士 大音 康毅

[redacted]

明　細　書

1. 考案の名称

ロッカーアーム室の給油装置

2. 実用新案登録請求の範囲

(1)　クランク室内のオイルを送油通路および戻り通路を通してロッカーアーム室へ循環させる給油装置において、前記戻り通路のクランク室側をタペットの動きにより開閉可能にし、クランク室が負圧のとき該タペットにより前記戻り通路を開き負圧でオイルの戻りを助勢するよう構成して成るロッカーアーム室の給油装置。

(2)　送油通路にクランク室からロッカーアーム室へ向うオイルの流れを許す逆止弁を設けることを特徴とする実用新案登録請求の範囲第1項記載のロッカーアーム室の給油装置。

3. 考案の詳細な説明

〔産業上の利用分野〕

本考案は頭上弁式（ＯＨＶ）エンジンのロッカーアーム室への給油装置の構造に関する。

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実開61-39116

〔従来技術〕

頭上弁式エンジンでは、吸気弁および排気弁が燃焼室の真上に配置され、これらの弁を作動するロッカーアームもシリンダヘッド上部に装着される。したがつて、ロッカーアームを含む動弁機構が納められるロッカーアーム室はシリンダヘッド上部に形成される。

このロッカーアーム室は、通常、ロッカーアームの揺動中心をなす軸受部、ロッカーアームと弁棒頂部との当接部、および弁棒を摺動案内するバルブガイドなどの運動部分を覆うヘッドカバー内に画成される。そこで、これらの運動部分は潤滑する必要があり、そのためロッカーアーム室への給油装置が設けられる。

しかし、頭上弁式エンジンでは、ロッカーアーム室がエンジン上部に位置しクランク室から離れているので、単に通路を設けてクランク室内のオイルを掻上げ飛散させるという通常の給油方法では確実な潤滑ができないという問題がある。

そこで、エンジンにオイルポンプを付加し、ロッカーアーム室へ強制給油する方法が採用されているが、従来のこの方法では、余分のオイルポンプおよび駆動機構を必要とし、このためエンジン構造の大型化および複雑化を招き、製造コストの上昇およびメインテナンス上の不利を招来するという問題があつた。

〔考案の目的〕

本考案の目的は、このような従来構造の問題を解決し、簡単な構造でロッカーアーム室を確実に潤滑しうる給油装置を提供することである。

〔考案の構成〕

本考案は、クランク室とロッカーアーム室との間に送油通路および戻り通路を設け、この戻り通路を、タペットの動きによりクランク室内が負圧のとき開き負圧吸引力を利用してオイルの戻りを助勢することにより上記目的を達成するものである。

すなわち、本考案によれば、クランク室内のオイルを送油通路および戻り通路を通してロッ

ーアーム室へ循環させる給油装置において、前記戻り通路のクランク室側をタペットの動きにより開閉可能にし、クランク室が負圧のとき該タペットにより前記戻り通路を開き負圧でオイルの戻りを助勢するよう構成して成るロッカーアーム室の給油装置が提供される。

〔実施例〕

以下、図面を参照して本考案の実施例を説明する。

第1図は一実施例に係るロッカーアーム室の給油装置を備えた頭上式エンジンを示し、クランク室1を形成するクランクケース1Aに軸承されたクランク軸2に連接棒3が連結され、その他端（小端部）にはシリンダ4に嵌されたピストン5が連結されている。

シリンダ4の上面にはシリンダヘッド6が気密状態で接合され、該シリンダヘッド6の接合部には燃焼室7が形成されている。また、シリンダヘッド6には、吸気通路8および排気通路9が形成されるとともに、これらの通路の燃焼

室７への開口部（ポート）を開閉する吸気弁10（図示せず）および排気弁１１が摺動可能に嵌合されている。これらの弁１０、１１はシリンダヘッド６に固定されたバルブガイド１２、１２に案内嵌合されている。さらに、シリンダヘッド６の上側には吸気弁１０および排気弁１１をバルブスプリング１３に抗して開弁作動する一対のロッカーアーム１４、１４が揺動可能に軸承されている。

然して、シリンダヘッド６の上側には前記ロッカーアーム１４、１４を囲むヘッドカバー15が密閉状態で接合され、その内部にロッカーアーム室１６が形成されている。

一方、クランクケース１Ａにはクランク軸２と平行にカム軸１７が軸承され、カムギヤ１８を介してクランク軸２の２分の１の角速度で回転駆動される。

カム軸１７のカム面１９と前記ロッカーアーム１４との間には、カムによつて往復動させられるタペット２０およびプッシュロッド２１が

設けられ、ロッカーアーム14を所定のタイミングで駆動するよう構成されている。これらのカム面19、タペット20およびプッシュロッド21は一対のロッカーアーム14、14に対応してそれぞれ吸気弁用および排気弁用のものが配置されている。こうして、エンジン運転すなわちクランク軸2の回転に応じ、吸気弁10および排気弁11がエンジンストローク（またはクランク回転角）中に所定のタイミングで開弁され、吸気および排気動作を行なうよう構成されている。

クランク室1には潤滑用のオイル22が所定の油面高さまで溜められ、クランク軸2に設けたオイルスプラッシャー23でオイル22を掻き上げて飛散させることにより、クランク大端部など所望部分に給油される。

次に、ロッカーアーム室16の給油装置を説明する。

シリンダ4およびシリンダヘッド6には、送油通路24および戻り通路25が形成されてい

る。

なお、クランク軸２は矢印Ａ方向に回転し、カム軸１７はこれと反対の矢印Ｂ方向に回転するよう設定されている。

前記送油通路２４のクランク室側開口（入口）２６は前記オイルスプラッシャー２３で掻き上げられて飛散するオイル２２が衝突する位置に設けられ、他端はロッカーアーム室１６内に開口している。また、送油通路２４の途中（図示の例ではシリンダ４とシリンダヘッド６との接合部）には、ロッカーアーム室１６へ向う方向へのみオイルの流れを許す逆止弁２７が設けられている。

前記戻り通路２５はロッカーアーム室１６内のオイルをクランク室１へ戻す通路であり、クランク室側の端部２８はタペット（図示の例では排気弁用のタペット）２０が嵌合する軸受面に開口している。タペット２０の表面には軸方向に延びる溝２９が形成され、該タペット２０の軸方向の動きにより前記戻り通路２５のクラ

ンク室側端２８を開閉するよう構成されている。すなわち、タペット２０の位置により戻り通路２５とクランク室１との連通を断続するよう構成されている。

第２図はエンジンの１サイクル（４ストローク）中のクランク室変動圧力Ｐと戻り通路２５の開閉タイミングを例示する。

第１図および第２図に示すごとく、排気弁用のタペット２０は排気弁開の期間Ｅにおいて上方へ移動し、該期間のほぼ中央の点θ_Eで最大リフト位置になり、該タペット２０に形成した溝１９はこの排気弁最大リフト点θ_Eを中心にしてクランク室圧力Ｐが負圧になる所定範囲Ｓで戻り通路２５に連通するよう設定されている。それ以外の範囲（期間）では第１図に示すように開口２８がタペット２０で閉じられている。

なお、第２図中には吸気弁用のタペットがリフトする期間に対応する吸気弁開の期間Ｇも例示されている。

こうして、戻り通路２５のクランク室側２８

はタペット２０の動きにより開閉し、クランク室１が負圧のとき該タペット２０により該クランク室１に連通し、この負圧の吸引力によりオイル戻りを助勢するよう構成されている。

以上の構成によれば、運転時オイルスプラッシャー２３で掻き上げられ飛散されるオイル22はその運動エネルギーで送油通路２４を通して上方へ送られ、ロッカーアーム室１６内へ供給される。この場合、途中に逆止弁２７を設けたので、オイルがロッカーアーム室１６へ到達する前に重力で逆戻りすることを防止できる。また、逆止弁２７はクランク室１が正圧のとき開き方向に付勢され、負圧のとき閉じ方向に付勢されるので、クランク室変動圧力Ｐをも送油作用に有効に利用することができる。

ロッカーアーム室１６に送り込まれたオイルは、所望個所、例えば各ロッカーアーム１４、１４の揺動軸受部および弁（吸、排気弁１０、１１）との押圧接触部、並びに各弁棒とバルブガイド１２、１２との嵌合部などを潤滑した後、

戻り通路25およびタペット20の溝29を通して再びクランク室1へ戻される。この場合、タペット20の動きにより、戻り通路25はクランク室1が負圧のとき開くので、負圧吸引力によつてオイル戻りが助勢される。

こうして、クランク室変動圧力Pを利用したポンプ作用により、ロッカーアーム室16へのオイル循環を促進することができ、もつて、ロッカーアーム室16内の潤滑を確実に行なうことができる。

特に、戻り通路25からのオイルの戻り機能を強化したので、オイルが弁棒とバルブガイド12との嵌合隙間から燃焼室7へ流入することを防止でき、無駄なオイル消費および白煙の発生をなくすことができる。特にエンジンが傾斜した際の上記問題点を解決出来る。

また、別途オイルポンプを設けることを要しないので、簡単でコンパクトな構造で確実な給油を行なうことができ、製造コストを低減およびメインテナンスの容易化を達成することもで

きる。

なお、上記実施例では、第２図に示すごとく戻り通路連通の期間Ｓをその全範囲でクランク室変動圧力Ｐが負圧になるよう選定したが、これは負圧が正圧より優勢であれば範囲の一部に正圧時を含むよう選定することも可能である。

さらに、上記実施例では排気弁用のタペット２０で戻り通路２５を開閉するよう構成したが、クランク室変動圧力Ｐの特性にもよるが、吸気弁用のタペットで戻り通路２５を開閉するよう構成することもできる。

また、送油通路２４および戻り通路２５はその全長または一部を適宜パイプ等で形成することもできる。更に図示の実施例ではホリゾンタルシャフト型エンジンで説明したが本考案はバーチカル・シャフト型エンジンにも適用出来る。

〔考案の効果〕

以上の説明から明らかなごとく、本考案によれば、簡単かつコンパクトな構造でロッカーアーム室を確実に潤滑しうる給油装置が得られる。

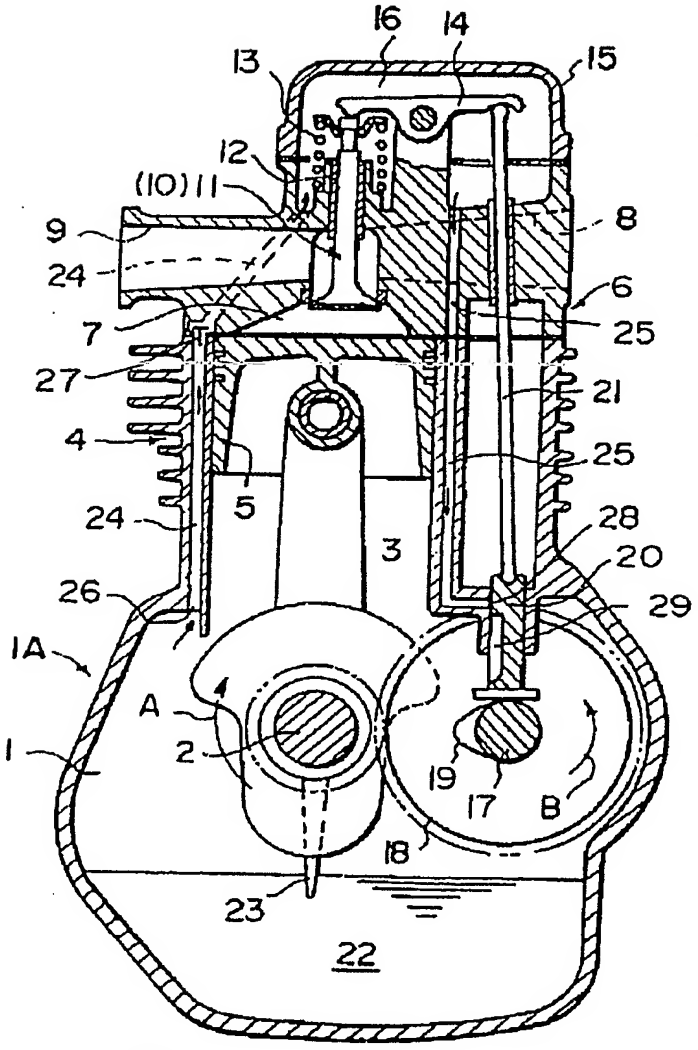
4. 図面の簡単な説明

第１図は本考案の一実施例に係るロッカーアーム室の給油装置を備えた頭上弁式エンジンの縦断面図、第２図は第１図のタペットの動きによる戻り通路の連通タイミングＳとクランク室変動圧力Ｐとの関係を例示するグラフである。

１…クランク室、　１６…ロッカーアーム室、
１７…カム軸、　２０…タペット、
２１…プッシュロッド、２２…オイル、
２４…送油通路、　２５…戻り通路、
２７…逆止弁、　２９…溝。

代理人　弁理士　大　音　康　毅

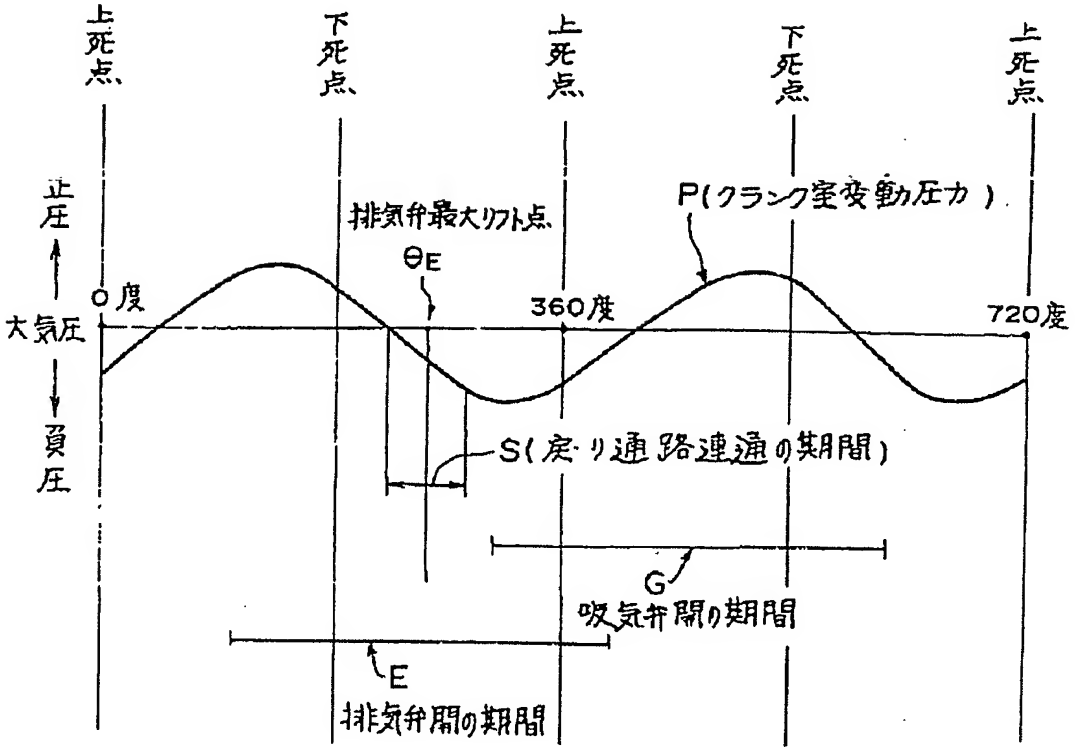
第 1 図



1---クランク室　22---オイル　27---逆止弁
16---ロッカーアーム室　24---送油通路　29---溝
20---タペット　25---戻り通路

223

第 2 図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P(クランク室変動圧力)
S(戻り通路連通の期間)
G
吸気弁開の期間
E
排気弁開の期間

E5e

(12) JAPANESE UTILITY MODEL APPLICATION LAID-OPEN NO. 61-39416

(43) LAID-OPEN DATE: March 12, 1986

(51) INT'L. CL.: F 01 M 9/10, 9/06

(54) TITLE OF THE INVENTION:

LUBRICATION APPARATUS FOR ROCKER ARM CHAMBER

(21) UTILITY MODE APPLICATION SERIAL NO.: 59-124834

(22) FILING DATE: August 16, 1984

(72) INVENTORS: TAKADA, Toshiyuki

MISAWA, Yoshiji

(71) APPLICANT: Kawasaki Jyu-kogyo Kabushiki Kaisha

SPECIFICATION

1. TITLE OF THE INVENTION

LUBRICATION APPARATUS FOR ROCKER ARM CHAMBER

2. WHAT IS CLAIMED IS:

(1) A lubrication apparatus for circulating oil stored in a crank chamber to a rocker arm chamber via an oil supply path and a return path, wherein the return path on the crank chamber side is opened and closed by a motion of a tappet, and wherein when the pressure in the crank chamber is lower than the atmospheric pressure, the return path is opened so as to promote the return rate of the oil making use of the lower pressure in the crank chamber.

(2) The lubrication apparatus according to claim 1, wherein a check valve is provided to the oil supply path in order to allow oil flow from the crank chamber to the rocker arm chamber.

3. DETAILED DESCRIPTION OF THE INVENTION

[Field of the Industrial Utility]

The present invention relates to a structure of a lubrication apparatus for lubricating a rocker arm chamber of an overhead-valve (OHV) engine.

[Description of Prior Art]

In overhead-valve engines, an induction valve and an exhaust valve are positioned directly above the combustion chamber, and the rocker arm for activating these valves is also provided above the cylinder head. Thus, the rocker arm chamber in which the valve activation mechanism, including the rocker arm, is accommodated is formed above the cylinder head.

The rocker arm chamber is generally defined inside the head cover which encloses the motional components including a bearing, which is the center of the swing of the rocker arm, an abutment between the rocker arm and the valve stem, and a valve guide for guiding the valve stem in a slidable manner. Since these motional components must be lubricated, a lubrication apparatus for the rocker arm chamber is used.

However, since in the overhead-valve engine the rocker arm chamber is located above the engine, apart from the crank chamber, the rocker arm chamber can not be reliably lubricated by a conventional lubrication method in which an oil flow path is formed and the oil in the crank chamber is paddled and splashed into the rocker arm chamber.

In order to overcome this problem, adding an oil pump to the engine has been proposed and actually employed. However, since this technique requires an extra oil pump and a driving mechanism, the engine structure inevitably becomes large and complicated, which results in the increased manufacturing cost and inconvenience in maintenance.

[Objective of the Invention]

Therefore, it is an object of the invention to overcome these problems in the prior art, and to provide a lubrication apparatus which can reliably lubricate the rocker arm chamber with a simple structure.

[Summary of the Invention]

The above-mentioned object is achieved by providing an oil supply path and a return path between a crank chamber and a rocker arm chamber, and opening the return path by a motion of a tappet when the pressure in the crank chamber is lower than the atmospheric pressure, thereby promoting the return rate of oil making use of the suction due to the lower pressure.

In particular, a lubrication apparatus for circulating oil stored in a crank chamber to a rocker arm chamber via a oil supply path and a return path is provided according to the invention. The return path on the crank chamber side is opened and closed by a motion of a tappet. When the pressure in the crank chamber is lower than the atmospheric pressure, the return path is opened so as to promote the return rate of the oil making use of the lower pressure in the crank chamber.

[Preferred Embodiment]

The preferred embodiment of the invention will be described in detail with reference to the attached drawings.

Fig. 1 illustrates an overhead-valve engine having a lubrication apparatus for rocker arm chamber according to an embodiment of the invention. One end of a coupling rod 3 is connected to a crank shaft 2 received by a crank case 1A which defines a crank chamber 1. The other end (i.e., the narrower end) of the coupling rod 3 is connected to a piston 5 which is fit into a cylinder 4.

The top face of the cylinder 4 is connected a cylinder head 6 in an air-tight manner, and a combustion chamber 7 is formed in the connected portion between the cylinder 4 and the cylinder head 6. An induction path 8 and an exhaust path 9 are also formed in the cylinder head 6, and an induction valve 10 (not shown) and an exhaust valve 11 are fit into the cylinder head 6 in a slidable manner in order to open and close the openings (or the ports) of the induction path 8 and the exhaust path 9 which communicate with the combustion chamber 7. A pair of rocker arms 14 are supported by a shaft in a pivotable manner on the cylinder head 6. The rocker arms 14 move the induction valve 10 and the exhaust valve 11 toward the open positions against the valve spring 13.

A head cover 15 is put on the cylinder head 6 in an air-tight manner so as to enclose the pair of rocker arms 14, and a rocker arm chamber 16 is formed inside the head cover 15.

In the lower part, a cam shaft 17 extends in parallel to the crank shaft 2, and is received by the crank case 1A. The cam shaft is rotated via a cam gear 18 at an angular velocity of one half (1/2) of the crank shaft 2.

A pair of tappets 20 and a pair of push rods 21, which are reciprocated by a cam, are provided between the cam surfaces 19 of the cam shaft 17 and the rocker arms 14 so as to drive the rocker arms 14 at a predetermined timing. Each rocker arm 14 corresponds to one of the induction valve and the exhaust valve, and each cam surface 19, tappet 20 and push rod 21 are associated with one of the rocker arms 14. The induction valve 10 and the exhaust valve 11 are opened at a predetermined timing during the engine stroke (or the rotation of the crank) according to the revolution of the engine, that is, the rotation of the crank shaft 2, whereby the induction and exhaust operations are performed.

The crank chamber 1 contains lubrication oil 22 up to a predetermined height. The oil 22 is paddled and splashed by the

oil splasher 23 which is fixed to the crank shaft 2 in order to lubricate a desired part, such as the broader end of the crank.

Next, the lubrication apparatus for the rocker arm chamber 16 will be described below.

An oil supply path 24 and a return path 25 are formed in the cylinder 4 and the cylinder head 6.

The crank shaft 2 is rotated in the direction indicated by the arrow A, and the cam shaft 17 is rotated in the opposite direction indicated by the arrow B.

The opening (i.e., the entrance) 26 on the crank chamber side of the oil supply path 24 is located at a position to which the oil 22 paddled and splashed by the oil splasher 23 directs. The other end of the oil supply path 24 is opened in the rocker arm chamber 16. A check valve 27 which allows the oil flow only in the direction to the rocker arm chamber 16 is provided in the middle of the oil supply path 24. In the example shown in Fig. 1, the check valve 27 is provided at the connection part between the cylinder 4 and the cylinder head 6.

The return path 25 is a path, through which the oil returns to the crank chamber 1 from the rocker arm chamber 16. The end portion 28 on the crank chamber side is opened toward the bearing face, into which the tappet (for the exhaust valve in the example shown in Fig. 1) 20 is fit. A groove 29 is formed on the surface of the tappet 20 along the axial direction. The aperture 28 on the crank chamber side of the return path 25 is opened and closed by the motion of the tappet 20 in the axial direction. In other words, the connection and disconnection between the return path 25 and the crank chamber 1 is controlled by the position of the tappet 20.

Fig. 2 is a graph showing the relation between the variable pressure P in the crank chamber and the opening/closing timing of the return path 25 in a cycle (i.e., 4 strokes) of the engine.

As shown in Figs. 1 and 2, the tappet 20 for the exhaust valve moves upward during the opening period E of the exhaust valve, and reaches the maximum lifted position at a point θ_E almost in the middle of the period E. The groove 19 formed in this tappet 20 is designed so that the groove 19 is in communication with the return path 25 within a predetermined range S centered on the maximum lifted pint θ_E, in which range the pressure P in the crank chamber becomes negative with respect to the atmospheric pressure. In the period other than this range S, the opening 28 is closed by the tappet 20.

Fig. 2 also shows Period G, in which the tappet for the induction valve is lifted.

In this fashion, the return path 25 on the crank chamber 28 side is opened and closed by the motion of the tappet 20. In particular, the return path 25 is in communication with the crank chamber 1 via the tappet 20 when the pressure P in the crank chamber 1 is negative with respect to the atmospheric pressure, thereby promoting the oil return rate making use of the suction force due to the negative pressure.

With this structure, oil 22 which is paddled and splashed by the oil splasher 23 during the driving moves upward via the oil supply path 24 with its kinetic energy, and reaches the rocker arm chamber 16. In this case, the check valve 27 provided in the middle of the oil supply path 24 can prevent the oil from returning to the crank chamber due to the gravity before it reaches the rocker arm chamber 16. The check valve 27 is forced in the opening direction when the pressure of the crank chamber 1 is positive with respect to the atmospheric pressure, and is forced in the closing direction at a negative pressure. Thus, the variable pressure P in the crank chamber 1 is efficiently used to promote the oil supply effect.

The oil supplied to the rocker arm chamber 16 lubricates

desired portions, for example, the swinging bearing of each rocker arm 14, pressurized contacting portions between the rocker arms 14 and the valves (induction and exhaust valves 10 and 11), and frictional portions between each valve stem and the valve guide 12. Then, the oil passes through the return path 25 and the groove 29 of the tappet 20, and returns to the crank chamber 1. Since the return path 25 is opened due to the motion of the tappet 20 when the pressure of the crank chamber 1 is negative, the oil return rate is promoted by the negative-pressure suction force.

Thus, the oil circulation to the rocker arm chamber 16 is improved by the pumping effect making use of the variable pressure P of the crank chamber, and inside the rocker arm room 16 is reliably lubricated.

In particular, the enhanced oil return structure in the return path 25 can prevent the oil from flowing into the combustion chamber 7 from the gap between the valve stem and the valve guide 12. As a result, oil consumption can be reduce, while undesirable white smoke can be eliminated, even if the engine is inclined.

This structure does not require an extra oil pump. Accordingly, lubrication of the rocker arm chamber can be reliably performed with a simple and compact structure, which yields further advantages, such as reduced manufacturing cost and facilitated maintenance.

Although, in the example shown in Fig. 2, the return path communicating period S is set so that the variable pressure P of the crank chamber is negative throughout the period S, a positive pressure range may be partially included in the return path communicating period S as long as the negative pressure is dominant over the positive pressure.

The return path 25 is opened and closed using the tappet 20 for the exhaust valve in the above-described embodiment. However, the tappet for the induction valve may also be used to open and

close the return path 25.

In addition, some or all of the oil supply path 24 and the return path 25 length can consist of a suitable pipe or the like. The embodiment in the drawings was explained using a horizontal shaft-type engine, but the invention can also be applied to a vertical shaft-type engine.

[Effect of the Invention]

As clarified in the explanation above, the invention is able to provide a lubrication apparatus with a simple, compact structure that is able to reliably lubricate a rocker arm chamber.

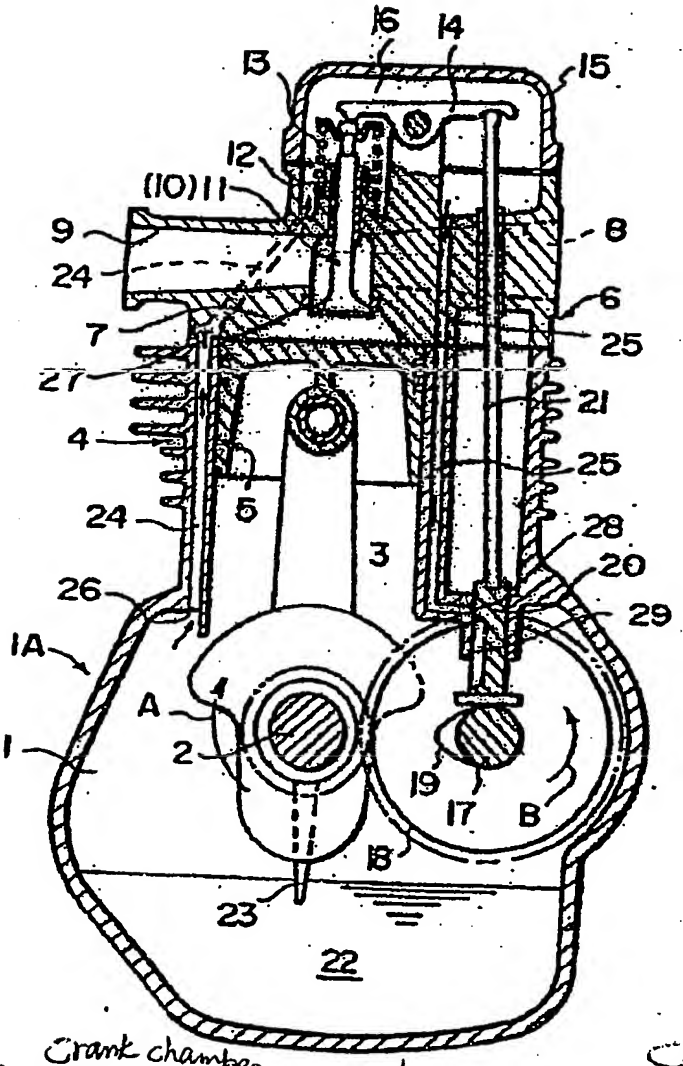
4. Brief Explanation of the Drawings

Fig. 1 illustrates an overhead-valve engine having a lubrication apparatus for a rocker arm chamber according to an embodiment of the invention. Fig. 2 is a graph showing the relation between the variable pressure P and the return path communication timing S based on the operation of the tappet in Fig. 1.

1 ... crank chamber	16 ... rocker arm chamber
17 ... cam shaft	20 ... tappet
21 ... push rod	22 ... oil
24 ... oil supply path	25 ... return path
27 ... check valve	29 ... groove

Agent Yasutaka Oto, Patent Attorney

第 1 図



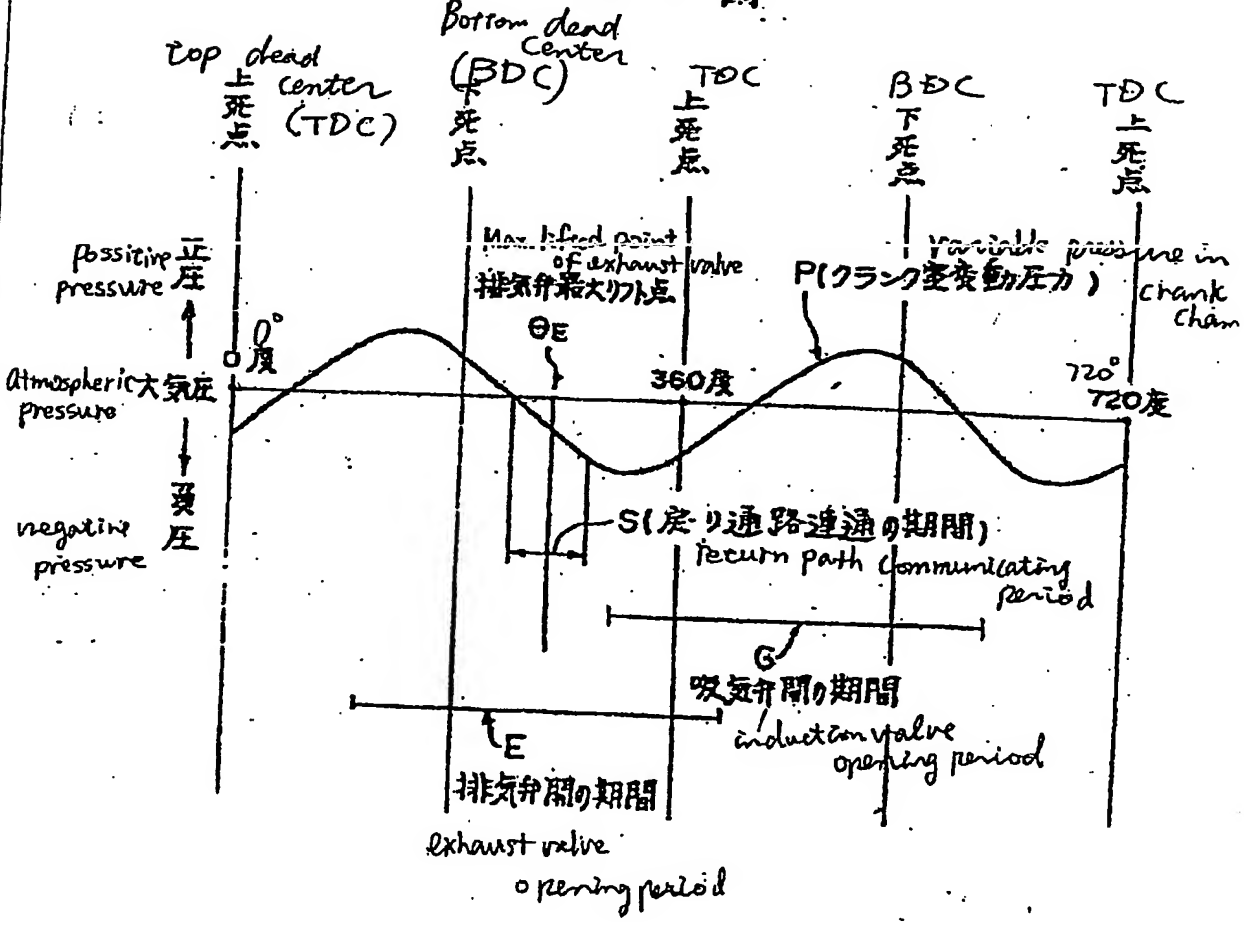
Crank chamber
1---クランク室
16---ロッカーアーム室
20---タペット
Tappet
rocker arm chamber

oil
22---オイル
24---送油通路
25---戻り通路
return path
Oil supply path

check valve
27---逆止弁
29---溝 groove

223

第 2 図


Top dead center (TDC)
上死点
Bottom dead center (BDC)
下死点
TDC
上死点
BDC
下死点
TDC
上死点
positive pressure
正圧
Atmospheric pressure
大気圧
negative pressure
負圧
Max lifted point of exhaust valve
排気弁最大リフト点
θE
0°
0度
360度
720°
720度
P(クランク室変動圧力)
Variable pressure in crank cham
S(戻り通路連通の期間)
Recurn path communicating period
G
吸気弁開の期間
induction valve opening period
E
排気弁開の期間
exhaust valve opening period

大 吉 康

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NOTICE OF ALLOWANCE AND FEE(S) DUE

00757 7590 08/11/2004

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60610

EXAMINER	
KAMEN, NOAH P	
ART UNIT	PAPER NUMBER
3747	

DATE MAILED: 08/11/2004

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/666,924	09/19/2003	Robert G. Everts	10512/41	6463

TITLE OF INVENTION: OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1330	$300	$1630	11/12/2004

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 07/04) Approved for use through 04/30/2007.

Notice of Allowability	Application No.	Applicant(s)	
	10/666,924	EVERTS ET AL.	
	Examiner	Art Unit	
	Noah Kamen	3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment and terminal disclaimer of 7/19/04*.

2. ☒ The allowed claim(s) is/are *8-13*.

3. ☒ The drawings filed on *9/19/03* are accepted by the Examiner.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Noah Kamen
Primary Examiner
Art Unit: 3747

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/666,924	09/19/2003	Robert G. Everts	10512/41	6463

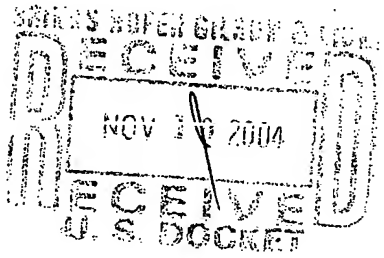
757 7590 11/04/2004

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60610

EXAMINER	
KAMEN, NOAH P	
ART UNIT	PAPER NUMBER
3747	

DATE MAILED: 11/04/2004

Please find below and/or attached an Office communication concerning this application or proceeding.



SUPPLEMENTAL Notice of Allowability	Application No. 10/666,924	Applicant(s) EVERTS ET AL.	
	Examiner Noah Kamen	Art Unit 3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☐ This communication is responsive to _____.

2. ☐ The allowed claim(s) is/are _____.

3. ☐ The drawings filed on _____ are accepted by the Examiner.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
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2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 9/19/03
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Noah Kamen
Primary Examiner
Art Unit: 3747

FORM PTO-1449	SERIAL NO. New Application	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT To Be Assigned
(use several sheets if necessary)	APPLICANT(S): Robert G. Everts & Katsumi Kurihara	

REFERENCE DESIGNATION U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER Number-Kind Code (if known)	DATE	NAME	CLASS/ SUBCLASS	FILING DATE
JK	A1	2,559,134	07/03/51	G.R. Steele		
	A2	2,980,089	08/59	Sampietro		
	A3	3,757,882	09/11/73	Honda		
	A4	4,031,622	06/77	Alexander		
	A5	4,100,909	07/78	Nakano et al.		
	A6	4,380,216	04/83	Kandler		
	A7	4,391,041	07/05/83	Porter-Bennett		
	A8	4,404,936	09/83	Tatebe et al.		
	A9	4,430,906	02/84	Holtzberg et al.		
	A10	4,485,770	12/84	Saka et al.		
	A11	4,508,068	04/85	Tuggle et al.		
	A12	4,510,897	04/85	Hatz et al.		
	A13	4,563,986	01/14/86	Nakano		
	A14	4,601,267	07/86	Kronich		
	A15	4,649,874	03/87	Sonoda et al.		
	A16	4,662,322	05/87	Tamba et al.		
	A17	4,662,323	05/87	Moriya		
	A18	4,674,146	06/87	Tuggle et al.		
	A19	4,688,529	08/25/87	Mitadera et al.		
	A20	4,716,861	01/88	Fujikawa et al.		
	A21	4,736,717	04/88	Fujikawa et al.		
	A22	4,762,098	08/88	Tamba et al.		
	A23	4,817,738	04/04/89	Dorner et al.		
	A24	4,841,929	06/89	Tuggle et al.		
	A25	4,846,123	07/89	Bolton, Jr.		
	A26	4,848,846	07/89	Yamada et al.		
	A27	4,881,496	11/89	Kronich		
	A28	4,936,271	06/90	Nagashima et al.		
	A29	4,969,434	11/90	Nakagawa		

EXAMINER Komen	DATE CONSIDERED 11/3/02

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449	SERIAL NO. New Application	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT To Be Assigned
(use several sheets if necessary)	APPLICANT(S): Robert G. Everts & Katsumi Kurihara	

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER Number-Kind Code (if known)	DATE	COUNTRY	CLASS/ SUBCLASS	TRANSLATION YES OR NO
NK	A30	172,166	09/34	Switzerland		
	A31	558,839	01/44	United Kingdom		
	A32	30-12702	06/55	Japan		
	A33	939,895	10/63	United Kingdom		
	A34	51-123416	10/76	Japan		
	A35	56-85509	07/81	Japan		
	A36	63-38542	02/88	Japan		
	A37	1-253553	10/89	Japan		
	A38	GB2 129 054 A	05/10/84	United Kingdom		
	A39	DE 3335962 A1	05/02/85	Germany		

EXAMINER INITIAL		OTHER ART – NON PATENT LITERATURE DOCUMENTS (Include name of author, title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date page(s), volume-issue number(s), publisher, city and/or country where published.
NK	A40	Conley, Imagawa, Kurihara, Olsen, Rickard, SAE Technical Paper Series, *the New Ryobi 26.2cc, OHV, 4-Stroke Engine for Hand Held Power Equipment Applications,* August 26-28, 1996
	A41	Conley,k Olsen, Kurihara, Rickard and Hermann, SAE Technical Paper Series, *The Development of a Durable Cost Effective, Overhead Valve Train for Application to Small, 4-Cycle Engines,* August 26-28, 1996
	A42	Conley and Asher, IMPRO 96 Conference Proceedings, *Team Management Practices and Development of the AC 4-cycle Engine,* 1996
	A43	Conley, Suchdev, Olsen, Kurihara and Rickard, Society of Automotive Engineers, Inc. *The Optimization of a 26.2cc, OHV, 4-Cycle Engine Aspiration System to Achieve 1999 CARB Emissions Standards,* August 1996
	A44	James G. Conley, *Experience with the Selection of Prototyping Techniques During the Rapid Development of a Commercial 4-Cycle Engine,* February, 1995
	A45	Kurihara and Conley, Society of Automotive Engineers of Japan, Inc., *Design Considerations for Overhead Valve Train in Small High Speed Four-Cycle Engines,* October 1997
	A46	*Features of Honda Generator "Super Watt 300",* 1995 (w/translation)
	A47	Honda Generator Catalog, 1993

EXAMINER	Kellen	DATE CONSIDERED	11/3/02

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449	SERIAL NO. New Application	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT To Be Assigned
(use several sheets if necessary)	APPLICANT(S): Robert G. Everts & Katsumi Kurihara	

EXAMINER INITIAL	OTHER ART – NON PATENT LITERATURE DOCUMENTS (Include name of author, title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date page(s), volume-issue number(s), publisher, city and/or country where published.	
NC	A48	Popular Science, Judith Anne Gunther, *The Little Engine That Could*, March, 1993, pp. 90-93
NC	A49	W. Beitz and K.H. Küttner, Engineering Manual, 1983, pp. 1-4

EXAMINER Kramer	DATE CONSIDERED 11/3/04

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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Date of Deposit: November 12, 2004

BRINKS
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&LIONE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of:	ROBERT G. EVERTS, et al.
Appln. No.:	10/666,924
Filed:	September 19, 2003
For:	OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD
Attorney Docket No:	10512/41

Examiner: KAMEN, NOAH P.

Art Unit: 3747

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U.S. Patent and Trademark Office
P. O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CONTINUED EXAMINATION (37 C.F.R. § 1.114)

Sir:

Applicant(s) requests continued examination of the above-identified application under 37 C.F.R. §1.114.

☒ Submission under 37 CFR 1.114 (*check at least one of the following*):

- ☐ Previously submitted:
  - ☐ Applicant(s) requests nonentry of any previously-filed unentered amendments.
  - ☐ Please enter and consider the Amendment After Final Under 37 C.F.R. §1.116 previously filed on_____
  - ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
  - ☐ Other: _____
- ☒ Attached is/are:
  - ☒ An Information Disclosure Statement
  - ☐ An Amendment to the written description, claims, or drawings
  - ☐ New Arguments and/or New Evidence in support of Patentability
  - ☐ Other: _____

☐ Request for suspension of action:

Applicant(s) hereby request suspension of action on the above-identified application under 37 C.F.R. §1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; requires Processing Fee under 37 C.F.R. §1.17(i)).

☐ Small Entity Status:

- ☐ Applicant hereby asserts entitlement to claim small entity status under 37 CFR §§ 1.9 and 1.27.
- ☐ A small entity statement or assertion of entitlement to claim small entity status was filed in prior application no._____/_____ and such status is still proper and desired.
- ☐ Is no longer desired.

☒ Applicant(s) calculate the following fees to be due in connection with this Request:

- ☒ A Request fee of $790 under 37 C.F.R. §1.17(e).
- ☐ A suspension processing fee of $_____ under 37 C.F.R. §1.17(i).
- ☐ An additional filing fee of $_____ under 37 C.F.R. §1.16 (_____ additional independent claims and/or _____ additional total claims).
- ☐ An extension fee of $_____ under 37 C.F.R. §1.17(a) for a _____-month extension of time.

☒ Fee payment to cover the above-enumerated fee(s):

- ☒ A check in the amount of $790 is enclosed.
- ☐ Please charge Deposit Account No. 23-1925 (BRINKS HOFER GILSON & LIONE) in the amount of $_____. A copy of this Request is enclosed for this purpose.
- ☐ A payment by credit card in the amount of $_____ (Form PTO-2038 is attached).
- ☒ The Commissioner is hereby authorized to charge payment of any additional filing fees required under 37 CFR § 1.16 and any patent application processing fees under 37 CFR § 1.17 associated with this paper (including any extension fee required to ensure that this paper is timely filed), or to credit any overpayment, to Deposit Account No. 23-1925 (BRINKS HOFER GILSON & LIONE). A copy of this Request is enclosed for this purpose.

Respectfully submitted,

11/12/04
Date

Robert S. Mallin (Reg. No. 35,596)

"Express Mail" mailing label number EV 325 993 875 US

Date of Deposit: November 12, 2004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of:	Robert G. Everts ET AL.		
Appln. No.:	10/666,924	Examiner:	KAMEN, NOAH P.
Filed:	September 19, 2003	Art Unit:	3747
For:	OPERATOR CARRIED POWER TOOL HAVING A FOUR-CYCLE ENGINE AND AN ENGINE LUBRICATION METHOD		
Attorney Docket No:	10512/41		

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

In accordance with the duty of disclosure under 37 C.F.R. §1.56 and §§1.97-1.98, and more particularly in accordance with 37 C.F.R. §1.97(b), Applicants hereby cite the following reference(s):

U.S. PATENTS

Patent No.	Date	Inventor
2,559,134	07/03/1951	G.R. Steele
2,697,457	12/21/1954	Lawrence
2,980,089	08/1959	Sampietro
3,323,504	06/06/1967	Jacobi
3,372,718	03/12/1968	Irgens
3,757,882	09/11/1973	Honda
3,977,078	08/31/1976	Fittinger, Jr.
4,031,622	06/1977	Alexander
4,100,909	07/1978	Nakano et al.
4,286,675	09/01/1981	Tuggle
4,380,216	04/1983	Kandler
4,391,041	07/05/1983	Porter-Bennett
4,404,936	09/1983	Tatebe et al.
4,430,906	02/1984	Holtberg et al.
4,485,770	12/1984	Saka et al.
4,508,068	04/1985	Tuggle et al.
4,510,897	04/1985	Hatz et al.

Patent No.	Date	Inventor
4,563,986	01/14/1986	Nakano
4,601,267	07/1986	Kronich
4,649,874	03/1987	Sonoda et al.
4,662,322	05/1987	Tamba et al.
4,662,323	05/1987	Moriya
4,674,146	06/1987	Tuggle et al.
4,688,529	08/25/1987	Mitadera et al.
4,716,861	01/1988	Fujikawa et al.
4,736,717	04/1988	Fujikawa et al.
4,762,098	08/1988	Tamba et al.
4,817,738	04/04/1989	Dorner et al.
4,841,929	06/1989	Tuggle et al.
4,846,123	07/1989	Bolton, Jr.
4,848,846	07/1989	Yamada et al.
4,881,496	11/1989	Kronich
4,936,271	06/1990	Nagashima et al.
4,969,434	11/1990	Nakagawa

FOREIGN PATENT DOCUMENTS

Document No.	Date	Country
SW 172,166	09/1934	Sweden
GB 558,839	01/1944	Great Britain
JP 30-12702	06/1955	Japan
GB 939,895	10/1963	Great Britain
JP 51-123416	10/1976	Japan
JP 56-85509	07/1981	Japan
JP 61-39416	03/12/1986	Japan
JP 61-39417	03/12/1986	Japan
JP 63-38542	02/1988	Japan
EP 0 294 786	06/08/1988	Europe
JP 1-253553	10/1989	Japan
GB2 129 054	05/10/1984	Great Britain
DE 3335962	05/02/1985	Germany

OTHER ART

Conley, Imagawa, Kurihara, Olsen, Rickard, SAE Technical Paper Series, *The New Ryobi 26.2cc, OHV, 4-Stroke Engine for Hand Held Power Equipment Applications*, August 26-28, 1996

Conley, Olsen, Kurihara, Rickard and Harmann, SAE Technical Paper Series, *The Development of a Durable Cost Effective, Overhead Valve Train for Application to Small, 4-Cycle Engines*, August 26-28, 1996

Conley and Asher, IMPRO 96 Conference Proceedings, *Team Management Practices and Development of the AC 4-Cycle Engine*, 1996

Conley, Suchdev, Olsen, Kurihara and Rickard, Society of Automotive Engineers, Inc., *The Optimization of a 26.2cc, OHV, 4-Cycle Engine Aspiration System to Achieve 1999 CARB Emissions Standards*, August 1996

James G. Conley, *Experience with the Selection of Prototyping Techniques During the Rapid Development of a Commercial 4-Cycle Engine*, February 1995

Kurihara and Conley, Society of Automotive Engineers of Japan, Inc., *Design Considerations for Overhead Valve Train in Small High Speed Four-Cycle Engines*, October 1997

Features of Honda Generator "Super Watt 300", 1995 (w/ translation)

Honda Generator Catalog, 1993

Popular Science, Judith Anne Gunther, *The Little Engine That Could*, March 1993, pp. 90-93

W. Beitz and K.H. Küttner, Engineering Manual, 1983, pp. 1-4

Applicants are enclosing Form PTO-1449 (two sheets), along with a copy of each listed reference for which a copy is required under 37 C.F.R. §1.98(a)(2). Applicants note that the references listed as B1, B3, B6, B8-B9, B11-B34, B35-B40, B43, and B45-B57 were previously submitted in an Information Disclosure Statement on September 19, 2003. However, the Examiner did not initial and return the form PTO-1449 indicating that these references had been considered. Applicants are also hereby submitting references listed as B2, B4-B5, B7, B10, B41-B42, and B44 which have not been previously submitted to the PTO, wherein a copy of the references listed as B41-

B42 and B44 are attached herewith. References listed as B41-B42 are being submitted with an English translation. Additionally, Applicants are re-submitting reference B47 with an English translation. Finally, Applicants are submitting communications from the European Patent Office that refer to references B10, B18, B26, B27, B34, B41, B42 and B47.

Applicants respectfully request the Examiner's consideration of the above reference(s) and entry thereof into the record of this application.

By submitting this Statement, Applicants are attempting to fully comply with the duty of candor and good faith mandated by 37 C.F.R. §1.56. As such, this Statement is not intended to constitute an admission that any of the enclosed references, or other information referred to therein, constitutes "prior art" or is otherwise "material to patentability," as that phrase is defined in 37 C.F.R. §1.56(a).

Applicants have calculated no fee to be due in connection with the filing of this Statement. However, the Director is authorized to charge any fee deficiency associated with the filing of this Statement to a deposit account, as authorized in the Transmittal accompanying this Statement.

Respectfully submitted,

November 12, 2004
Date

Robert S. Mallin (Reg. No. 35,596)

FORM PTO-1449	SERIAL NO. 10/666,924	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT 3747
(use several sheets if necessary)	APPLICANT(S): Robert G. Everts, et al.	

REFERENCE DESIGNATION **U.S. PATENT DOCUMENTS**

EXAMINER INITIAL		DOCUMENT NUMBER Number-Kind Code (if known)	DATE	NAME	CLASS/ SUBCLASS	FILING DATE
	B1	2,559,134	7/3/51	G.R. Steele		
	B2	2,697,457	12/21/1954	Lawrence		
	B3	2,980,089	8/59	Sampietro		
	B4	3,323,504	6/6/1967	Jacobi		
	B5	3,372,718	3/12/1968	Irgens		
	B6	3,757,882	9/11/73	Honda		
	B7	3,977,078	8/31/1976	Fittinger, Jr.		
	B8	4,031,622	6/77	Alexander		
	B9	4,100,909	7/78	Nakano et al.		
	B10	4,286,675	9/1/1981	Tuggle		
	B11	4,380,216	4/83	Kandler		
	B12	4,391,041	7/5/83	Porter-Bennett		
	B13	4,404,936	9/83	Tatebe et al.		
	B14	4,430,906	2/84	Holtberg et al.		
	B15	4,485,770	12/84	Saka et al.		
	B16	4,508,068	4/85	Tuggle et al.		
	B17	4,510,897	4/85	Hatz et al.		
	B18	4,563,986	1/14/86	Nakano		
	B19	4,601,267	7/86	Kronich		
	B20	4,649,874	3/87	Sonoda et al.		
	B21	4,662,322	5/87	Tamba et al.		
	B22	4,662,323	5/87	Moriya		
	B23	4,674,146	6/87	Tuggle et al.		
	B24	4,688,529	8/25/87	Mitadera et al.		
	B25	4,716,861	1/88	Fujikawa et al.		
	B26	4,736,717	4/88	Fujikawa et al.		
	B27	4,762,098	8/88	Tamba et al.		
	B28	4,817,738	4/4/89	Dorner et al.		
	B29	4,841,929	6/89	Tuggle et al.		
	B30	4,846,123	7/89	Bolton, Jr.		
	B31	4,848,846	7/89	Yamada et al.		
	B32	4,881,496	11/89	Kronich		
	B33	4,936,271	6/90	Nagashima et al.		
	B34	4,969,434	11/90	Nakagawa		

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449	SERIAL NO. 10/666,924	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT 3747
(use several sheets if necessary)	APPLICANT(S): Robert G. Evans, et al.	

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER Number-Kind Code (if known)	DATE	COUNTRY	CLASS/ SUBCLASS	TRANSLATION YES OR NO
	B35	SW 172,166	9/34	Switzerland		No
	B36	GB 558,839	1/44	Great Britain		N/A
	B37	JP 30-12702	6/55	Japan		No
	B38	GB 939,895	10/63	Great Britain		N/A
	B39	JP 51-123416	10/76	Japan		No
	B40	JP 56-85509	7/81	Japan		No
	B41	JP 61-39416	3/12/1986	Japan		Yes
	B42	JP 61-39417	3/12/1986	Japan		Yes
	B43	JP 63-38542	2/88	Japan		No
	B44	EP 0 294 786	6/8/1988	Europe		N/A
	B45	JP 1-253553	10/89	Japan		No
	B46	GB2 129 054	5/10/84	Great Britain		N/A
	B47	DE 3335962	5/2/85	Germany		No

EXAMINER INITIAL		OTHER ART – NON PATENT LITERATURE DOCUMENTS (Include name of author, title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date page(s), volume-issue number(s), publisher, city and/or country where published.
	B48	Conley, Imagawa, Kurihara, Olsen, Rickard, SAE Technical Paper Series, *The New Ryobi 26.2cc, OHV, 4-Stroke Engine for Hand Held Power Equipment Applications*, August 26-28, 1996
	B49	Conley, Olsen, Kurihara, Rickard and Harmann, SAE Technical Paper Series, *The Development of a Durable Cost Effective, Overhead Valve Train for Application to Small, 4-Cycle Engines*, August 26-28, 1996
	B50	Conley and Asher, IMPRO 96 Conference Proceedings, *Team Management Practices and Development of the AC 4-Cycle Engine*, 1996
	B51	Conley, Suchdev, Olsen, Kurihara and Rickard, Society of Automotive Engineers, Inc., *The Optimization of a 26.2cc, OHV, 4-Cycle Engine Aspiration System to Achieve 1999 CARB Emissions Standards*, August 1996
	B52	James G. Conley, *Experience with the Selection of Prototyping Techniques During the Rapid Development of a Commercial 4-Cycle Engine*, February 1995
	B53	Kurihara and Conley, Society of Automotive Engineers of Japan, Inc., *Design Considerations for Overhead Valve Train in Small High Speed Four-Cycle Engines*, October 1997
	B54	*Features of Honda Generator "Super Watt 300"*, 1995 (w/ translation)
	B55	Honda Generator Catalog, 1993
	B56	Popular Science, Judith Anne Gunther, *The Little Engine That Could*, March 1993, pp. 90-93
	B57	W. Beitz and K.H. Küttner, Engineering Manual, 1983, pp. 1-4

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/666,924	09/19/2003	Roderick Evens	10512/41	6463

EXAMINER	
KAMEN, NOAH P	

ART UNIT	PAPER NUMBER
3747	

DATE MAILED: 04/14/2005

757 7590 04/14/2005

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60610

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/666,924	EVERTS ET AL.	
	Examiner	Art Unit	
	Noah Kamen	3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *31 March 2005*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *8-19* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *8-19* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 7/1/05
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 8-19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kovacs (DE 3335962) in view of Takada et al (JP 61-39416).

Kovacs proposes to use a four cycle engine for a chain saw Takada et al disclose a four cycle engine comprising a cam 17, a valve cover 15 on the cylinder head. a splasher 23 that directs lubricant to the recited moving parts of the engine via oil passages 24, 25. Takada et al disclose that an advantage of the invention is a lubrication apparatus, which can lubricate the rocker arm chamber in a reliable and efficient manner with a simple and compact structure. Since this is important for a portable operator carried power tool, one of ordinary skill in the art would combine the engine of Takada with the tool of Kovacs.

Response to Arguments

Applicant's arguments, see the remarks on page 5, filed 3/31/05, with respect to Tuggle have been fully considered and are persuasive. The rejection of claims 14-19 based on Tuggle has been withdrawn.

Applicant's arguments filed 3/31/05 based on Kovacs and Takada have been fully considered but they are not persuasive. The applicants argue that Kovacs fails to explain how the disclosed engine could be used with a chain saw and that the engine is merely directed to an exhaust improvement; therefor the disclosure for use in a chainsaw is speculation. Furthermore, there is no teaching/motivation to combine the lubrication system of Takada et al

with Kovacs. That to combine the two references would result in an engine incapable of being hand-held/portable. The applicants assert that no hand-held 4-cycle engine was available anywhere else (see 1993 Popular Science, "The Little Engine That Could').

The examiner contends that while Kovacs does not show a clear reduction to practice of a hand-held 4-cycle engine, one of ordinary skill in the art would clearly understand that construction would involve merely miniaturization. The assertion that it had never been done before (at least on a commercial scale) is probably one of expense. Two-cycle engine have fewer parts than and easier to build. It is only with relatively new emission standards that the cost would become a secondary factor. Kovacs fails to disclose details of a lubrication system; therefor, one of ordinary skill in the art would be motivated to use the system of Takada et al for the advantages listed therein. Again, their combination would merely require miniaturization; albeit at a much greater expense. As previously mentioned, the fact that miniature 4-cycle engine had not existed before is deemed not an issue of technology, but one of expediency. Lastly, there are no limitations in the pending claims that deal with novel aspects on how to miniaturize the engine. The claims just recite "lightweight", "hand-held", "portable" with respect to KNOWN ENGINE CONSTRUCTION.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37

CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Noah Kamen whose telephone number is 571 272 4845. The examiner can normally be reached on M-Th 6:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Henry Yuen can be reached on 571 272 4856. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Noah Kamen
Primary Examiner
Art Unit 3747

nk

FORM PTO-1449	SERIAL NO. 10/666,924	CASE NO. 10512/41
LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT	FILING DATE September 19, 2003	GROUP ART UNIT 3747
(use several sheets if necessary)	APPLICANT(S): Robert G. Everts, et al.	

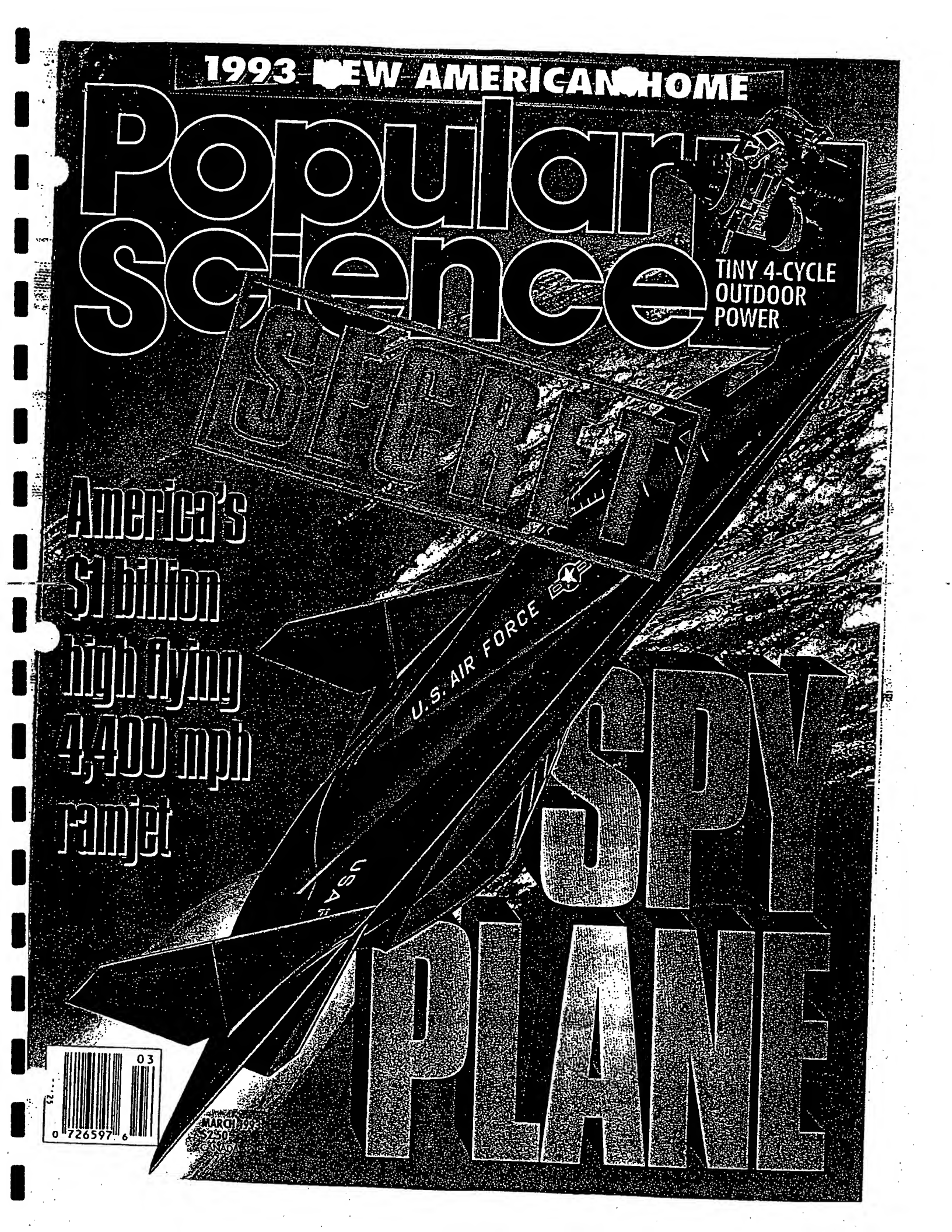
FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER Number-Kind Code (if known)	DATE	COUNTRY	CLASS/ SUBCLASS	TRANSLATION YES OR NO
NK	C1	DE 3525181	1/23/1986	Germany	—	Yes

EXAMINER INITIAL		OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)
NK	C2	Brockhaus Enzyklopädie, p. 302 (1970) – translation included
NK	C3	Demuth, *Viertakt-Modell-Motoren*, pp. 75-76, 78-80, and 95-96 (1983) – translation included

EXAMINER		DATE CONSIDERED	4/12/05

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.


1993 NEW AMERICAN HOME
Popular Science
TINY 4-CYCLE OUTDOOR POWER
America's $1 billion high flying 4,400 mph ramjet
U.S. AIR FORCE
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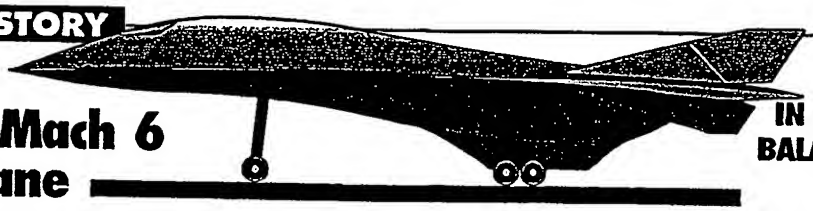
Popular Science

THE WHAT'S NEW MAGAZINE

MARCH 1993
Founded in 1872/Vol. 242, No. 3

COVER STORY



56 Secret Mach 6 spy plane

An eyewitness description, a secret Nevada test site, and a new look at advanced aeronautics paint a portrait of Aurora, America's newest secret reconnaissance aircraft. A Federation of American Scientists report also posits the existence of the plane, along with others flying in the Pentagon's "black world."

66 A house for all reasons

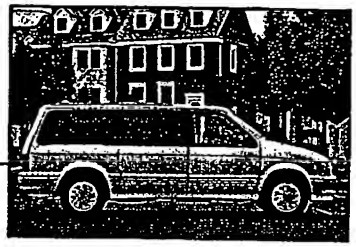
The architectural style may be classic Mediterranean villa, but the 1993 New American Home contains some of the most technologically advanced home-building products available today, complementing the home's energy-saving and environmentally friendly themes.

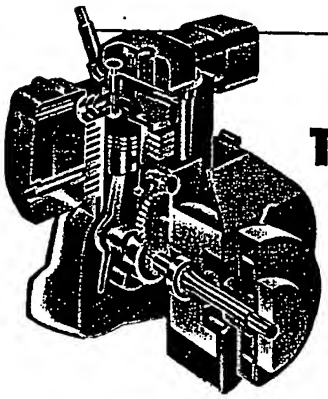
74 The unbearable lightness of space travel

Prolonged weightlessness in near-zero gravity could endanger human health, as well as NASA's plans for long missions. The ill effects include muscle-wasting and heart shrinkage. Here's how researchers are studying the problems—and hope to solve them.

80 Minivans to the max

Volkswagen EuroVan, Mercury Villager, Nissan Quest, and Dodge Grand Caravan: One is the tallest, two are the widest, and one is the longest. We tell you which is which and which is the best.





90 The little engine that could

This one-cylinder four-cycle gas-powered engine is lightweight enough for hand-held outdoor power equipment—and clean enough for stringent emissions standards that are coming soon.

COVER ILLUSTRATION BY KERRY LESLIE

THE LIGHT ENGINE THAT COULD

This four-cycle engine is lightweight enough for hand-held equipment and clean enough for California.

BY JUDITH ANNE GUNTHER

Here, claimed experts in the outdoor power tool industry, was a problem without a ready solution. How could they build a gas-powered engine small and powerful enough for consumers, yet sufficiently clean-burning to meet increasingly demanding legislation?

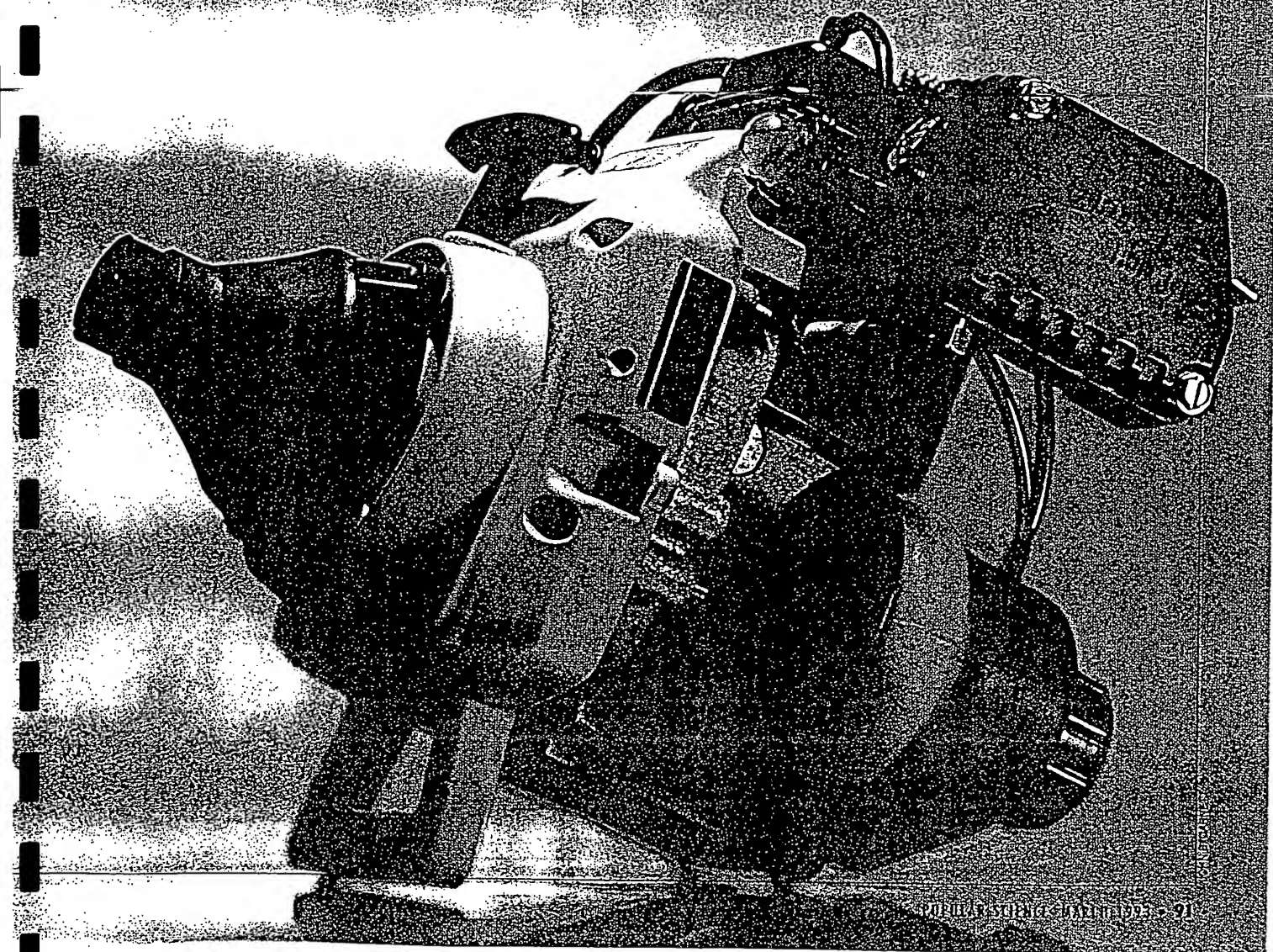
Now one manufacturer, Ryobi North America, the South Carolina-based subsidiary of the Japanese toolmaker, says it has an answer. Ryobi's CleanAir engine is a radically scaled-down 26cc four-cycle engine that deftly delivers one horsepower in an eight-pound package. And Ryobi is betting that this engine will heavily influence the hand-held outdoor power tools that consumers buy in the mid-1990s.

For decades, manufacturers have relied on two-cycle engines to power chain saws, trimmers, blowers, and other tools that require light weight and brute force, taking advantage of a power pulse with every crankshaft revolution ["Greener Pastures," July '92]. But such performance has its price—air pollution—and in 1990 the California Air Resources Board (CARB) established stringent emissions standards that will have to be met by all gas-powered utility products sold in that state. The CARB regulations, which take effect in two phases, in 1994 and then 1999, have been criticized by some manufacturers as being too difficult to meet in a relatively short period of time. (Discussions are underway between CARB and manufacturers to move the first-phase deadline back by one year.)

How did Ryobi get the jump on the industry? Partly by making the project a priority item as early as 1989 and partly by pushing the limits of small-engine technology. The CleanAir engine circumvents the exhaust-emissions problem inherent in a two-cycle engine mainly by employing its cousin, the four-cycle engine.

The project had sprung from a concept for a small-displacement, low-cost, four-stroke engine that had been proposed to Ryobi in 1988 by Robert Everts, an Arizona-based engineer whose company produced the first working prototype. Commonly used on heavier lawn and garden equipment, a four-cycle engine fires its ignition on every other revolution and uses conventional poppet valves to control the flow of the incoming fuel-air mixture and outgoing exhaust. This helps reduce the chance that some fuel will escape unburned. And unlike many two-cycle engine designs, the four-cycle does not require that the lubricating oil be mixed directly with the gasoline, a major cause of the blue smoke plume that routinely spits out of two-cycles.

"We started out with three criteria for this engine:



says Ryobi senior vice president William McLay. "First, it had to meet California's emissions standards. Second, it could not be any heavier than current two-cycle engines. Third, it couldn't cost significantly more than high-end engines. And we feel that the CleanAir engine meets these parameters."

In theory, building a small four-cycle engine might not seem difficult, but in reality Ryobi faced numerous design and manufacturing hurdles. Today's small four-cycle engines normally weigh 40 pounds and generate about 3.5 horsepower. The CleanAir engine, in comparison, weighs just eight pounds and generates one horsepower. Such dramatic downsizing required smaller components; some parts, such as the valves, didn't exist and had to be designed and manufactured specifically for this engine.

Still, industry experts are cautious when discussing the engine. "There's no magic here," remarks Glenn Keller of the Engine Manufacturers Association in Chicago. While he acknowledges the difficulties in design, he sums that "Ryobi has just miniaturized everything."

A logical analysis in the broad sense, but, as additional research indicates, something of an underestimate of the cleverness of the Ryobi engine design. Such a simplistic engine-shrinking could certainly have produced the low emissions levels and perhaps the necessary power output, but doubtfully could have done it at a competitive manufacturing cost. Here the CleanAir engine demonstrates some unique design solutions that give it a clear edge, at least for the time being.

"We are aware—at least it's rumored in the industry—that other manufacturers have made small four-cycle engines," McLay says. "But they're either polluting or very costly or too heavy." Likewise, tiny four-cycle engines used in another application—model airplanes—don't fit the bill for running trimmers and blowers. "That's a whole different power class," says McLay.

To operate a grass trimmer, he explains, a small four-cycle engine must turn at about 7,000 or 8,000 rpm—twice the speed of a mower-type engine. Increasing speed means increased heat, and possibly increased wear on engine parts. Although McLay won't reveal the metallurgy processes that were employed ("We hope it will take a while for our competitors to figure it out," he says), he does allude to alloys, heat-treating methods, and materials chosen for their lubricity.

To keep engine temperatures down, Ryobi engineers worked out an unusual two-piece cylinder head consisting of a lower casting that houses the combustion chamber and an upper section that encloses the rocker arms used to open the valves. This design permits cooling fins to be placed strategically next to some of the hottest areas of the engine—the exhaust valve and bridge area between the valves.

For all of the development effort Ryobi invested in it, the CleanAir engine must still be competitive with other products if it is to sell in the 49 states that *don't* have emissions regulations yet. (The EPA is reviewing emissions data of so-called utility engines; nationwide regulations may be announced by the end of 1993.)

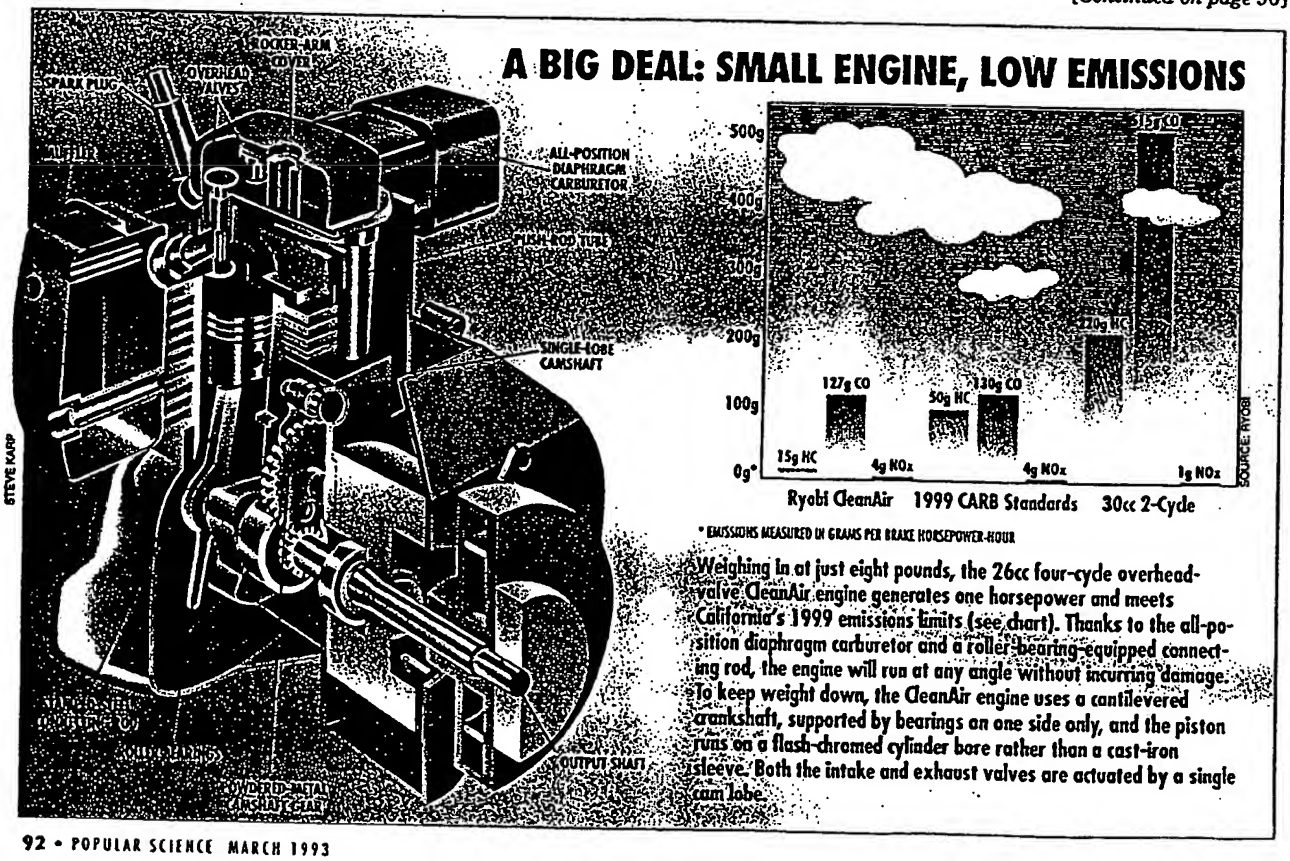
"Only certain people will buy a product because it is environmentally friendly," McLay acknowledges. Performance, he maintains, will be a major selling point.

The most significant benefit consumers will find is the more consistent power produced by four-strokes. "The characteristic of a two-cycle engine is that it has to be very high on the rpm curve to get the most torque output," he explains. "But a four-cycle has a flatter curve, so when the engine is working hard, it still produces the torque. As rpm drops, torque doesn't drop much at all."

Another plus inherent in a four-cycle engine is that it doesn't require a gas-oil mixture. Instead, lubricant is distributed by a dipper at the end of the connecting rod—the conventional

[*Continued on page 96*]

A BIG DEAL: SMALL ENGINE, LOW EMISSIONS



STEVE KARP

Weighing in at just eight pounds, the 26cc four-cycle overhead-valve CleanAir engine generates one horsepower and meets California's 1999 emissions limits (see chart). Thanks to the all-position diaphragm carburetor and a roller-bearing-equipped connecting rod, the engine will run at any angle without incurring damage. To keep weight down, the CleanAir engine uses a cantilevered crankshaft, supported by bearings on one side only, and the piston runs on a flash-chromed cylinder bore rather than a cast-iron sleeve. Both the intake and exhaust valves are actuated by a single cam lobe.

The little engine that could

[*Continued from page 92*]

splash-type system used in small four-cycles—which Ryobi claims will be effective even with the engine running inverted. By itself, it would seem unlikely that the dipper system could possibly live up to that assertion. That is, until you learn that both ends of the connecting rod ride on caged roller bearings (rather than conventional insert shells), which get along fine on very small amounts of oil. As a side benefit, the weight, cost, and power drain of an oil-circulating pump have been eliminated.

The caged roller bearings are fitted into a steel connecting rod that is built up from two separate stampings, rather than the usual casting or forging. The stamped parts are left and right sections; there is no separate bearing cap at the bottom end. This construction technique requires that the crankshaft be pressed together from individual pieces for ease of assembly, and here again Ryobi breaks from tradition by using a stamped counterweight section mated to a simple steel output shaft. Additionally, overall engine weight is kept low by the crankshaft's cantilevered design; the engine is supported in ball bearings only on the flywheel side, ending abruptly at the connecting rod.

The enlightened engineering doesn't end there, either. To eliminate a heavy iron cylinder sleeve, the CleanAir engine is built with a long-lasting, flash-chromed aluminum cylinder bore. The valve train operates from one cam lobe, using an ingenious follower mechanism that simultaneously converts the cam's rotation to the required reciprocating motion and also turns the action 90 degrees to line up with the ball-pivot rocker arms.

In addition to exhaust emissions, Ryobi addressed another form of pollution: noise. While the CleanAir engine's noise level is only a few decibels less than most engines, the biggest difference is its deeper pitch. "The improvement is the quality of the sound," says McLay. "High-pitched sounds and lower-pitched sounds at the same decibel level are two different experiences to the human ear."

Computer-aided-design technology played a major role in this process. "We incorporated a large-volume muffler, but what's more, we used computer-aided design to create noise-canceling baffling," he says. To reduce the noise generated by the gear drive, engineers designed gear profiles that would operate more quietly and then manufactured the gears in a powdered-metal material that provides some advantage in sound damping.

Now engineers are ironing out the last details, including smoothing the engine's vibrations. "We're still fine-tuning that," says McLay. "Four-cycle engines tend to vibrate more than two-cycles because they fire every other stroke."

A 1994 debut

The CleanAir engine will be manufactured almost entirely in Arizona and will first appear in a hand-held grass trimmer at the industry's exposition this summer in Louisville, Ky. Consumers can expect to see that product on store shelves in the first part of 1994. Meanwhile, McLay says Ryobi will consider applying the technology to other outdoor power tool products, such as brush cutters, cultivators, and leaf blowers, as well as licensing the engine to manufacturers of water pumps, mowers, and high-power washers. PS